

Daily report

07-05-2020

Analysis and prediction of COVID-19 for EU-EFTA-UK and other countries

Foreword

The present report aims to provide a comprehensive picture of the **pandemic situation of COVID-19** in the EU countries, and to be able to foresee the situation in the next coming days.

We employ an **empirical model**, verified with the evolution of the number of confirmed cases in previous countries where the epidemic is close to conclude, including all provinces of China. The model does not pretend to interpret the causes of the evolution of the cases but to permit the **evaluation of the quality of control measures made in each state** and a **short-term prediction of trends**. Note, however, that the effects of the measures' control that start on a given day are not observed until approximately 7-10 days later.

The model and predictions are based on two parameters that are daily fitted to available data:

- ✓ α : the velocity at which spreading specific rate slows down; the higher the value, the better the control.
- ✓ K : the final number of expected cumulated cases, which cannot be evaluated at the initial stages because growth is still exponential.

We show an individual report with 8 graphs and a table with the **short-term predictions** for different countries and regions. We are adjusting the model to **countries and regions** with at least 4 days with more than 100 confirmed cases and a current load over 200 cases. The **predicted period** of a country depends on the number of datapoints over this 100 cases threshold, and is of 5 days for those that have reported more than 100 cumulated cases for 10 consecutive days or more. For short-term predictions, we assign higher weight to last 3 points in the fittings, so that changes are rapidly captured by the model. The whole methodology employed in the inform is explained in the last pages of this document.

In addition to the individual reports, the reader will find an initial dashboard with a brief analysis of the situation in EU-EFTA-UK countries, some summary figures and tables as well as **long-term predictions** for some of them, when possible. These long-term predictions are evaluated without different weights to datapoints. We also discuss a specific issue every day.

Martí Català
Pere-Joan Cardona, PhD
*Comparative Medicine and Bioimage Centre of
Catalonia; Institute for Health Science Research
Germans Trias i Pujol*

Clara Prats, PhD
Sergio Alonso, PhD
Enric Álvarez, PhD
Miquel Marchena
David Conesa
Daniel López, PhD
*Computational Biology and Complex Systems;
Universitat Politècnica de Catalunya - BarcelonaTech*

With the collaboration of: Guillem Álvarez, Oriol Bertomeu, Laura Dot, Lavínia Hriscu, Helena Kirchner, Daniel Molinuevo, Pablo Palacios, Sergi Pradas, David Rovira, Xavier Simó, Tomás Urdiales

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(0) Executive summary – Dashboard

Global EU+EFTA+UK trends and needs

EU+EFTA+UK countries show a **sudden increase in new cases**. This is due to a one-day peak in **France**, that has jumped from the level of <1,000 daily new cases to 4,200, and a one-day peak in **United Kingdom**, that increases from 4,000 new cases to 6,200. This explains the excess in daily new cases at the European level, that increases until 17,300 new cases and breaks last days' trend. **Next days will be essential to elucidate if its is due to a delay in data reporting or if it encompasses deeper changes.**

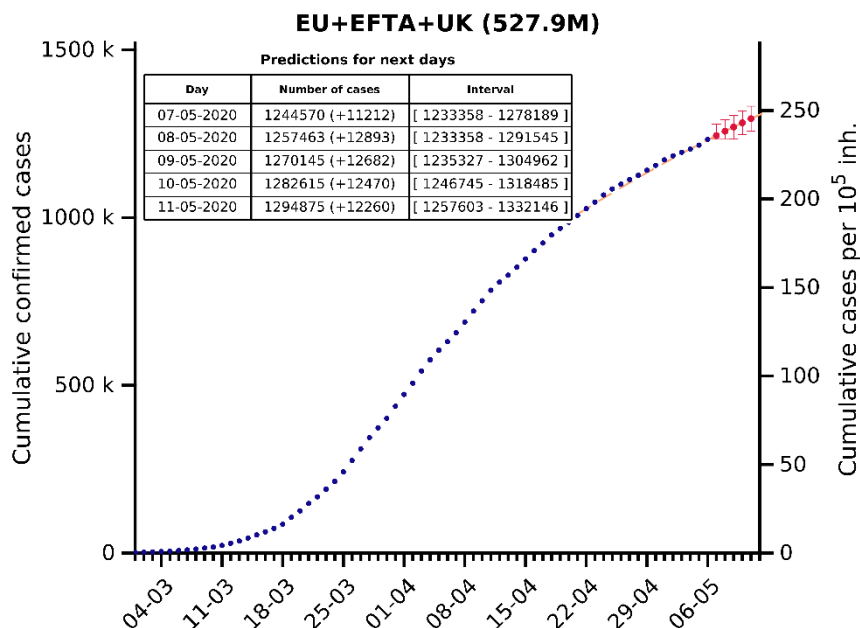
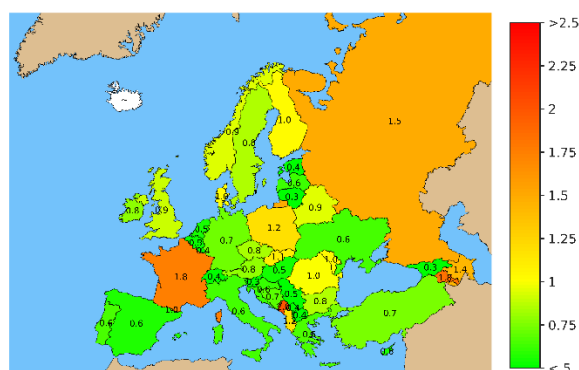
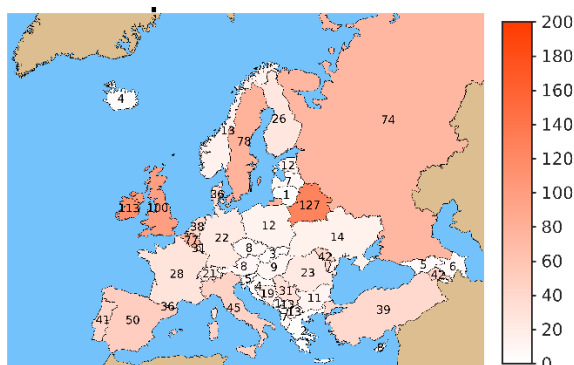
Total deaths have reached 140,000, but daily number is decreasing. If one week ago the rhythm of deaths was around 2,600, it has been reduced until around 1,850, now. The maximum number achieved was 5,090 on April 8th.

In the Analysis section we discuss the levels of risk that can be determined with EPG index. In particular, we focus on who to determine that a country is at low risk and that deconfinement measures can be implemented.

Trends for specific countries

Romania and **United Kingdom** are the only countries with a p_7 higher than 1. Highest number of reported cumulative deaths is found in **UK** (30,076) followed by **Italy** (29,684), **Spain** (25,857) and **France** (25,809). In relative terms, **Belgium** has reported 73.4 deaths per 10^5 inhabitants and is followed by **Spain** (55.8), **Italy** (49.9), **UK** (45.3) and **France** (39.9).

New! The map in the left shows cumulative incidence last 14 days (A_{14}). The map in the right shows current spreading rate per country (p).



Situation and trends per country

Table of current situation in EU countries. Colour scale is relative except when indicated, this means that it is applied independently to each column, and distinguishes best (green) from worst (red) situations according to each of the variables. **New!** Last column (EPG_{EST}) indicates EPG assessed with **estimated real 14-day attack rate** (see report from 22/04 for details). EPG_{REP} is calculated with **data reported by countries**. EPG_{REP} and EPG_{EST} **cannot be compared between them** because scales are different, but can be independently used for estimating risk of countries according to reported or estimated real situation, respectively.

Country	Reported data						Indexes		
	Cumulative cases	Attack rate /10 ⁵ inh.	Cumulative deaths	Mortality /10 ⁵ inh.	Active cases (last 14 days)	14-day attack rate /10 ⁵ inh.	$\rho_7^{(1)}$	$EPG_{REP}^{(2)}$	$EPG_{EST}^{(3)}$
Spain	220,325	475.4	25,857	55.8	23,419	50.5	0.64	33	383
Italy	214,457	360.9	29,684	49.9	27,130	45.7	0.75	34	483
United Kingdom	201,201	302.8	30,076	45.3	67,706	101.9	1.05	107	1,730
Germany	166,091	202.8	7,119	8.7	18,045	22.0	0.78	17	80
France	137,150	211.9	25,809	39.9	17,999	27.8	0.83	23	462
Belgium	50,781	447.1	8,339	73.4	8,892	78.3	0.60	47	798
Netherlands	41,319	243.2	5,204	30.6	6,477	38.1	0.76	29	370
Switzerland	29,977	349.8	1,504	17.5	1,791	20.9	0.68	14	73
Portugal	26,182	252.4	1,089	10.5	4,200	40.5	0.58	23	104
Sweden	23,918	243.1	2,941	29.9	7,914	80.4	0.89	72	1,074
Ireland	22,248	470.8	1,375	29.1	5,577	118.0	0.70	83	537
Austria	15,651	179.6	608	7.0	727	8.3	0.69	6	23
Poland	14,740	38.6	733	1.9	4,571	12.0	0.92	11	66
Romania	14,107	71.3	858	4.3	4,397	22.2	1.00	22	156
Denmark	9,983	174.8	506	8.9	2,071	36.3	0.89	32	175
Czech Republic	7,974	75.1	262	2.5	838	7.9	0.82	6	23
Norway	7,953	148.2	209	3.9	703	13.1	0.79	10	28
Finland	5,573	101.3	252	4.6	1,444	26.2	0.92	24	129
Luxembourg	3,851	668.6	98	17.0	197	34.2	0.88	30	NA
Hungary	3,150	32.3	383	3.9	866	8.9	0.80	7	102
Greece	2,663	23.8	147	1.3	255	2.3	0.83	2	11
Croatia	2,119	50.3	85	2.0	169	4.0	0.66	3	NA
Iceland	1,799	493.9	10	2.7	14	3.8	0.45	2	NA
Bulgaria	1,778	24.9	84	1.2	754	10.6	0.73	8	NA
Estonia	1,713	130.6	55	4.2	154	11.7	0.50	6	NA
Slovenia	1,448	69.7	99	4.8	95	4.6	0.49	2	NA
Slovakia	1,429	26.2	25	0.5	185	3.4	0.74	3	NA
Lithuania	1,428	49.1	48	1.7	30	1.0	NA	NA	NA
Latvia	900	45.7	17	0.9	139	7.1	0.74	5	NA
Cyprus	883	75.5	21	1.8	93	7.9	0.86	7	NA
Malta	484	112.8	5	1.2	40	9.3	NA	NA	NA
Liechtenstein	83	215.3	1	2.6	1	2.6	NA	NA	NA

Scale									
Worst	Worst	Worst	Worst	Worst	Worst	Worst	2.0	200	2000
Best	Best	Best	Best	Best	Best	Best	0.0	0	0

⁽¹⁾ ρ_3 is the average of 7 consecutive ρ , but can still fluctuate. ⁽²⁾ EPG stands for Effective Growth Potential. EPG_{REP} is obtained by multiplying attack rate of last 14 days per 10⁵ inhabitants (i.e. density of cases) by ρ_3 (a value related with effective reproduction number and that, therefore, determines the dynamics for subsequent days). EPG_{EST} is obtained by multiplying estimated real attack rate of last 14 days per 10⁵ inhabitants by ρ_3 .

Highlights for countries with highest number of reported cases

- ✓ UK and France show a sudden increase in new cases (from 4,400 to 6,200 and from 1,100 to 4,200, respectively). Italian and German new cases also increase but in a softer manner (from 1,000 to 1,400 and from 1,000 to 1,200, respectively), while Spanish slightly decrease (1,300 to 1,000).
- ✓ UK's ρ_7 remains at 1.1, while other countries remain at <1.

Time indicators by country

This table summarizes a few time indicators for each country: time since 50 cases were reported, time interval between an attack rate of $1/10^5$ inhabitants and an attack rate of $10/10^5$ inhabitants, and time interval between attack rates of 10 to 100 per 10^5 inhabitants (only for countries that have overtaken this threshold).

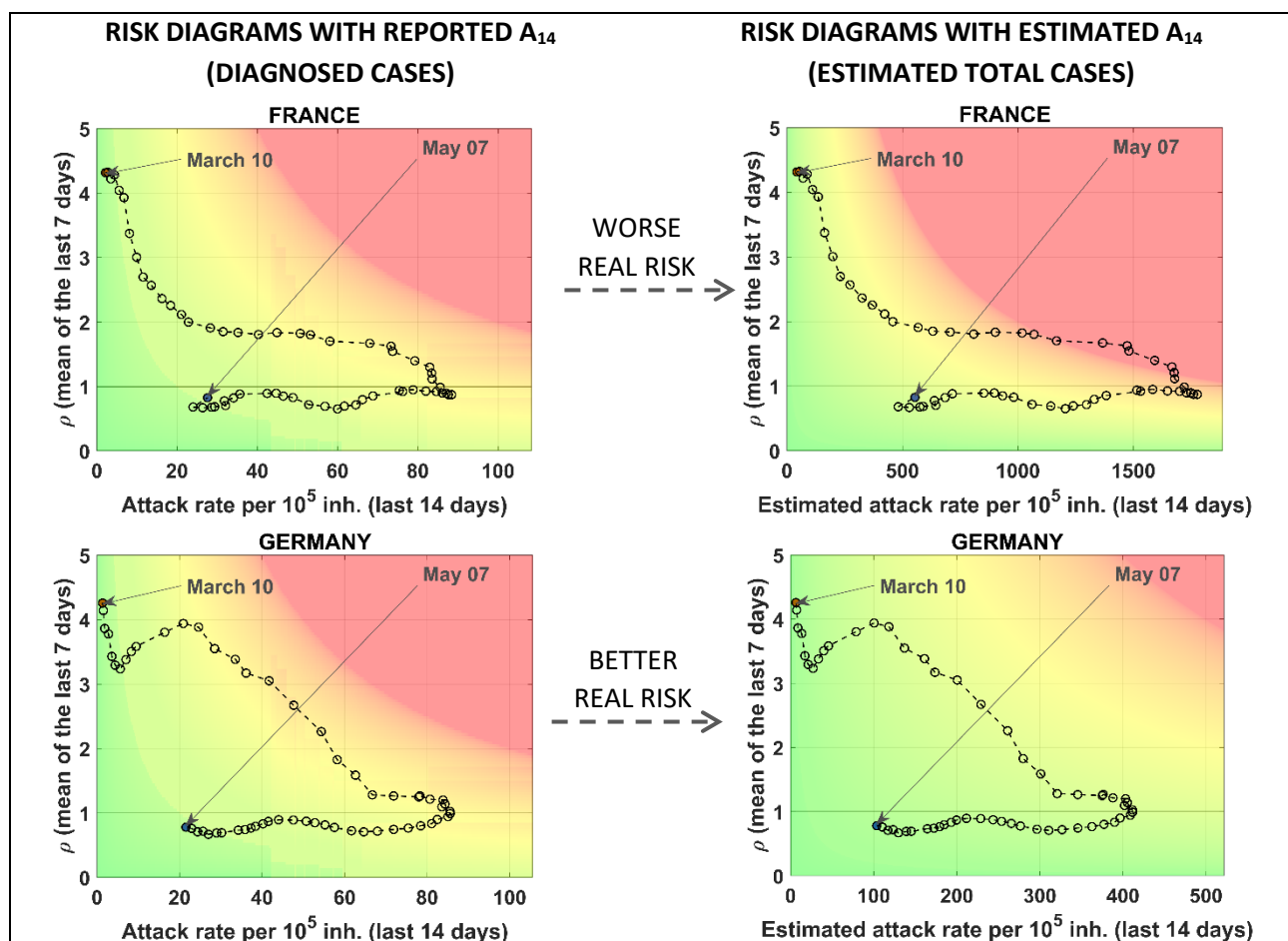
Countries	Days since the first 50 cases	Time interval between 1 and 10 cases / 10^5 inh. (days)	Time interval between 10 and 100 cases / 10^5 inh. (days)
Italy	75	11	16
France	69	10	20
Germany	69	12	17
Spain	67	7	12
United Kingdom	65	11	19
Norway	64	9	24
Switzerland	64	9	12
Netherlands	63	11	20
Sweden	63	10	28
Austria	62	10	14
Belgium	62	11	14
Greece	61	18	NA
Iceland	61	5	15
Denmark	59	4	30
Czech Republic	58	11	NA
Finland	57	12	NA
Portugal	57	9	15
Slovenia	57	6	NA
Ireland	56	8	18
Romania	56	15	NA
Estonia	55	5	30
Poland	55	17	NA
Bulgaria	53	27	NA
Luxembourg	53	6	7
Slovakia	53	24	NA
Croatia	52	12	NA
Latvia	51	12	NA
Cyprus	50	12	NA
Hungary	50	20	NA
Malta	49	8	34
Lithuania	48	9	NA
Liechtenstein	43	9	11

Analysis: Risk diagrams colour-code and the ability to do contact tracing

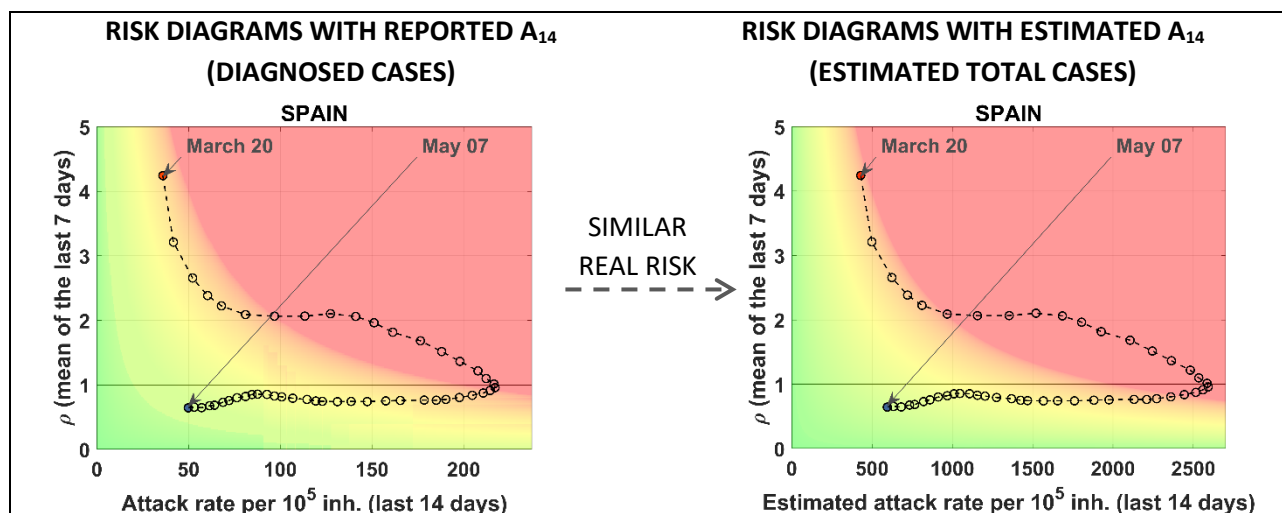
We showed yesterday the risk diagrams for Italy, Spain and their different regions in order to describe the evolution of the situation within different countries. As we have explained before, in these diagrams the X-axis is the 14-day attack rate (A_{14}). In the Y-axis we have the average level of epidemic growth during the last week (ρ_7), which gives an indication of number of contacts and the possibility of having similar infection chains in the recent future. The evolution of the country can be followed in this graph as a trajectory. Then, it can be used for planning the deconfinement process but, **how to establish a real risk from these diagrams?**

The value of A_{14} can be obtained from the number of reported cases or with the number of estimated cases. This is, we can use our estimation of real cases in the last 14 days in order to more properly assess the differences between countries regarding the ability to detect people. In a way, we correct different countries according to their Case Fatality Rates (CFR). Countries with low CFR have a large ability to detect while countries with large CFR are having problems with detection.

Four examples of risk diagrams are shown here below for France and Germany as examples of countries in very **different situation where reported (i.e., diagnosed with a test and registered by the country) and estimated (i.e., estimated from CFR data)**. On the left we use directly reported A_{14} , and on the right the estimated A_{14} . Colour scales are given by EPG_{REP} and EPG_{EST} , respectively ($EPG = \rho_7 \cdot A_{14}$).

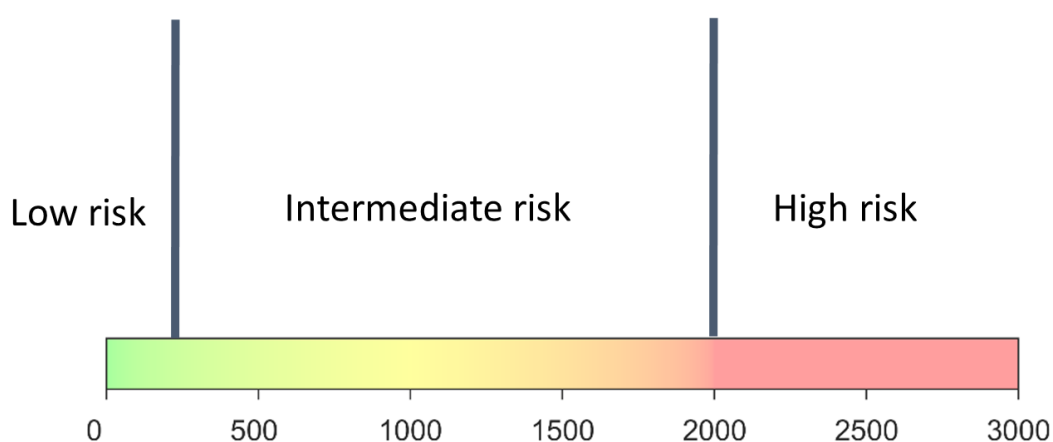


There are other countries, like Spain, where the assessment of the risk with reported or estimated cases provides equivalent results.



As important as having a fast way to assess the trajectory of the epidemics in any particular region, the key visual information comes from the colour behind each point. Red indicates large attack and growth rate and green a low number for both. However, the most important point of the colour-code is the criterion used to establish the borders between colours and how to link this colour with the local capacity of test and tracing. As we said yesterday, **policy makers can establish a local indicative scale following the criteria we establish for the colour. Today we focus on the definition of this colour-code which uses the estimated cases and not the reported cases as the rationale for its scale.** The risk diagram using reported cases uses the same colour code but dividing the EPG by 10.

As it can be seen in the graph below, we are using a level $EPG_{EST}=2000$ as our red. This means a 2,000 estimated people per 100,000 in A_{14} at growth rate 1. Similarly, we are taking one order of magnitude less ($EPG_{EST}=200$) as the **level for green**. The reason behind these colours is related with the ability to control the possible contagion chains compared with the number of PCR tests available.



We need first to assess present **capabilities to perform PCR tests to explain the choice of the green level**. We focus on PCR tests which are the only ones which guarantee a reasonably successful rate of detection and does not present a lot of false negatives (order of 10-15%).

Regarding the ability to do tests and control the epidemics with contact tracing, the total number of accumulated tests is not a useful figure. **The key figure is how many PCR tests per day per 100,000 people**

can a city, country or region perform. We will call this index DTL for Daily Testing Level. In this regard, the countries with more accumulated PCR tests are Italy and USA. They seem to have built one of the largest apparatus. Both Italy and the USA are managing to test roughly at $DTL = 100$. Heavy hit regions of Spain on the other hand are managing DTL at levels around 50.

This number, $DTL=50$, is key in our colour-code. This same number is roughly, the level of testing that South Korea had set up from the very beginning of the epidemics in the country ($DTL=20-40$). So, it is clear that with the appropriate low level of cases $DTL=50$ is the level where the epidemic can be controlled. Precisely, South Korea had a reported attack rate below 15 at the most and they controlled it while having $DTL=20$ at the very beginning.

If we consider that South Korea, given their initial CFR, detected at least around half of the infected population and that DTL was roughly half what most developed countries presently achieve, we can affirm that **having an estimated A_{14} below 100 makes the epidemics possible to control if the infrastructure to trace people is in place.**

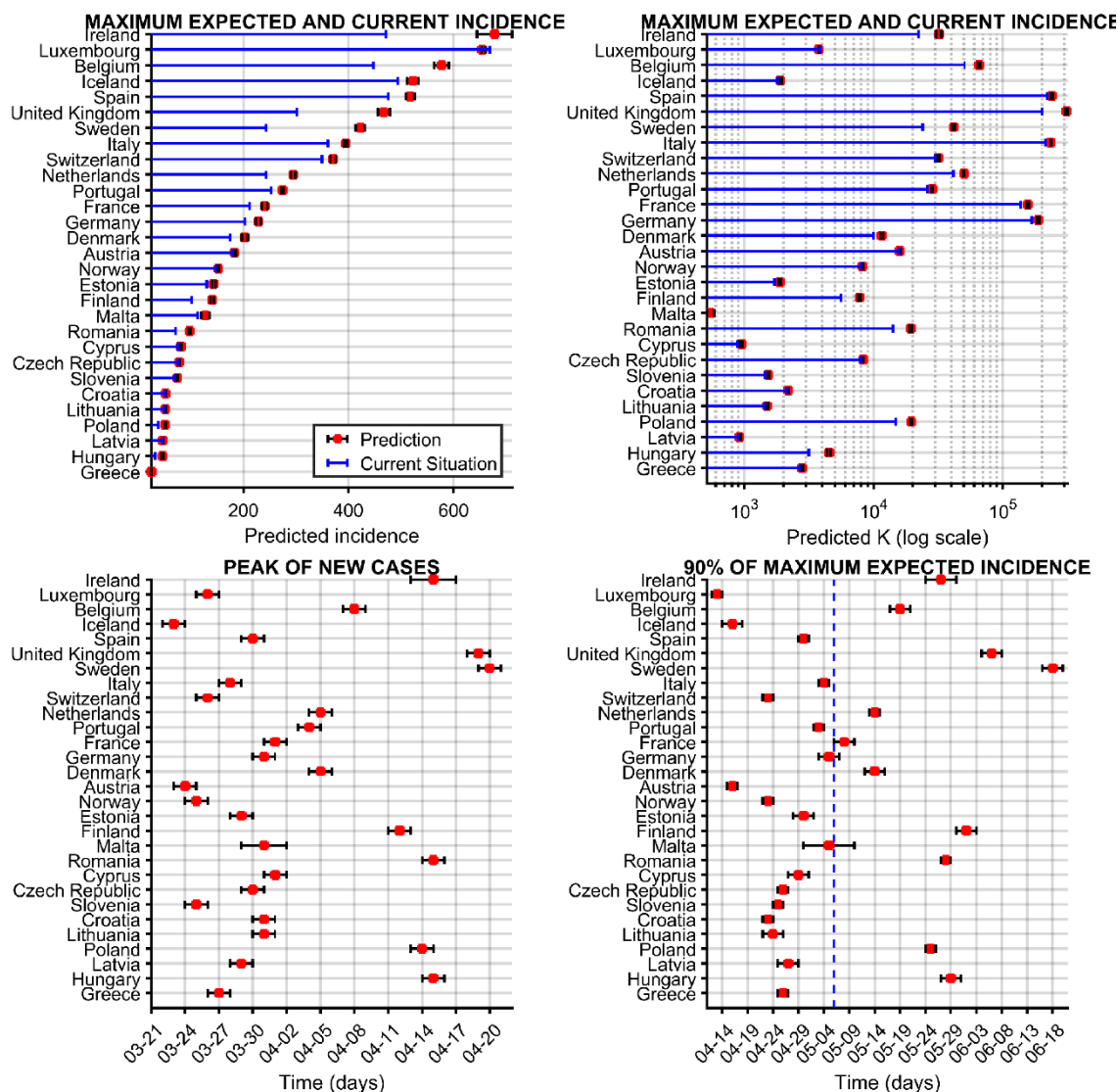
We state however, that **contact tracing at $A_{14}=200$ is perfectly manageable in countries that have the ability to perform PCR tests.** If we use again South Korea as an example, a $DTL=100$ will make the system reasonably equivalent. And still with $DTL=50$ we think that contact tracing is possible at $A_{14}=200$. Given that people spend roughly four-six days without symptoms, we have to be sure that DTL can trace the equivalent number of new cases as they become active. So, we state that **in order to be green you need, at least, to have $DTL > A_{14}/4$, or at least the same order. Since most countries can reach $DTL=50$ we set our green colour code to $A_{14} < 200$.** This fixes our green low risk level.

We can establish a relation now between the risk diagrams using estimated cases and reported cases. In this case, we could use the relation we observe in the diagnostic rate at each country. Given that different countries have different diagnostic rates but that the average in Europe is around 10%, we rescale by default the number by a factor 10. This is, in the risk diagram with reported cases the red level is not at $A_{14}=2000$ but at $A_{14}=200$. However, this change in colour-code between estimated and reported can be adapted from country to country if needed.

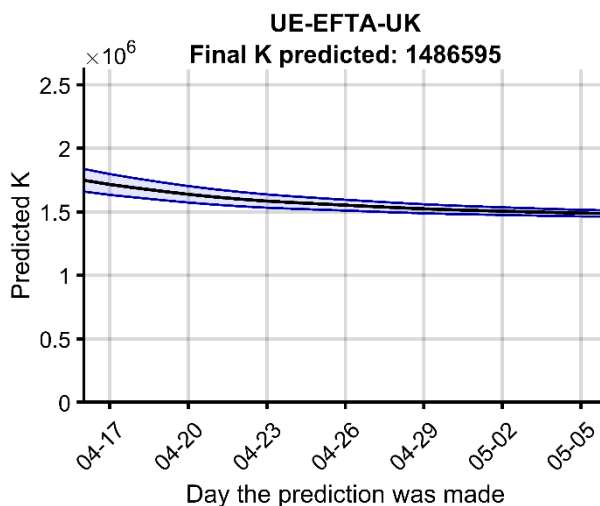
We finish recalling that having the ability to do test is not enough. Countries must assess their ability and infrastructure to do contact tracing and get the proper samples. We must not disregard however the complexity of scaling up the contact tracing procedure. It is not only the ability to go from $DTL=50$ to $DTL=100$ that is difficult, the ability to track the double of people and their contacts can be more difficult at this level.

Long-term predictions

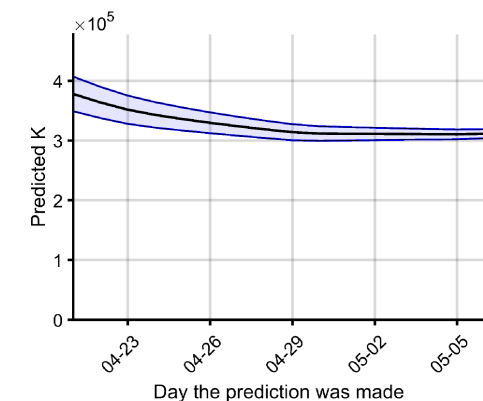
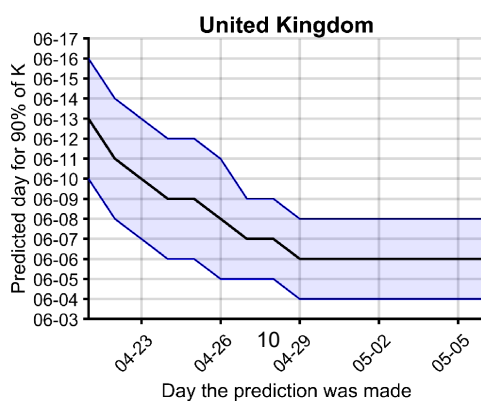
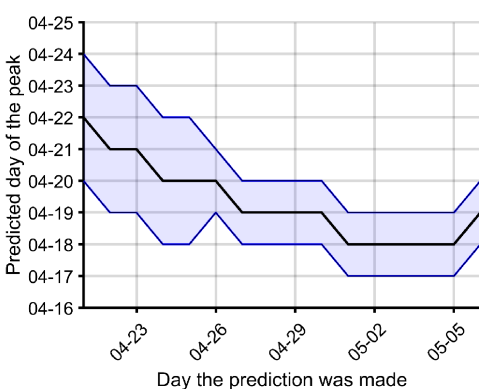
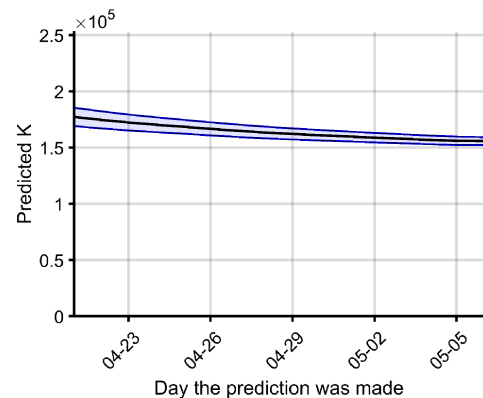
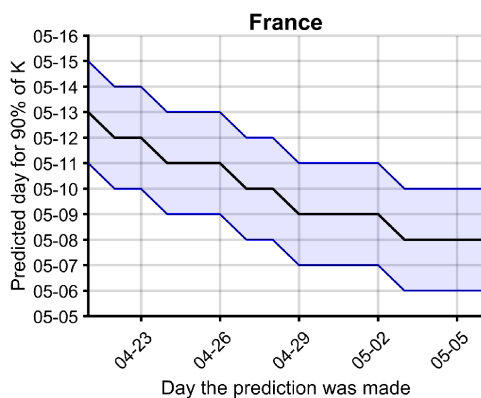
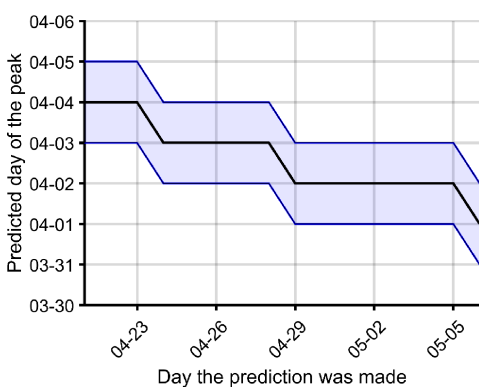
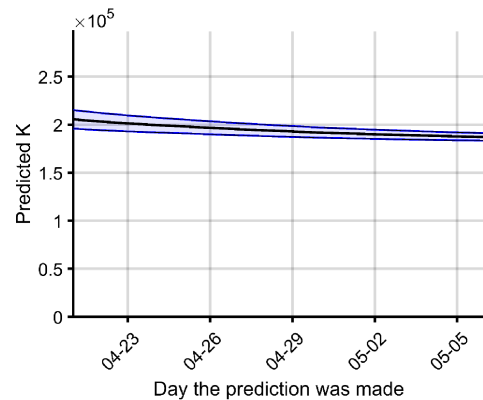
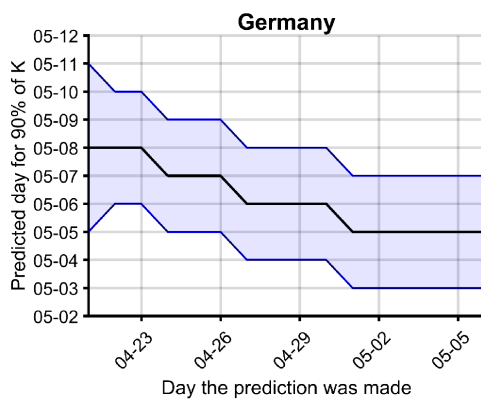
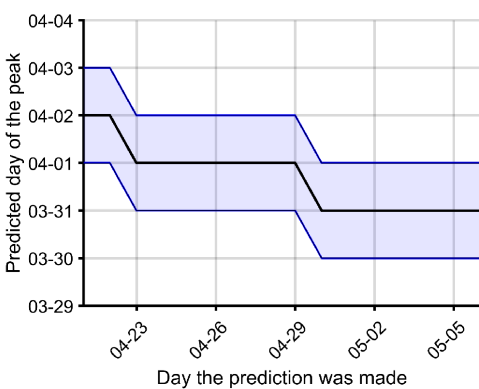
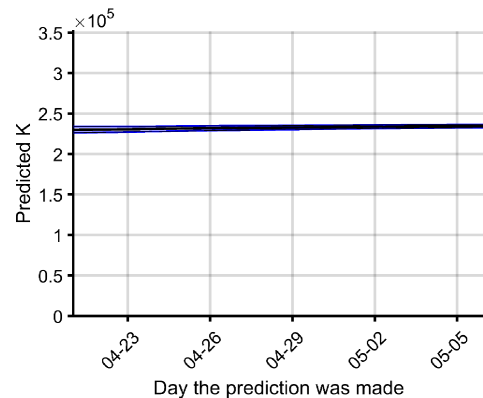
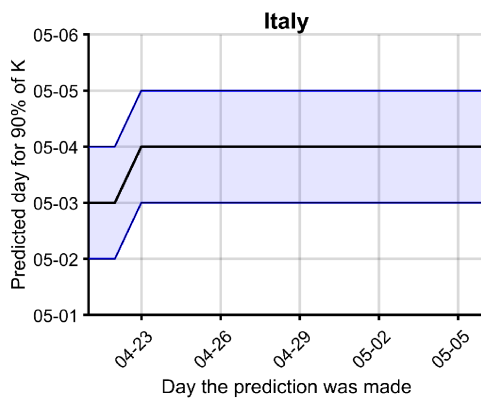
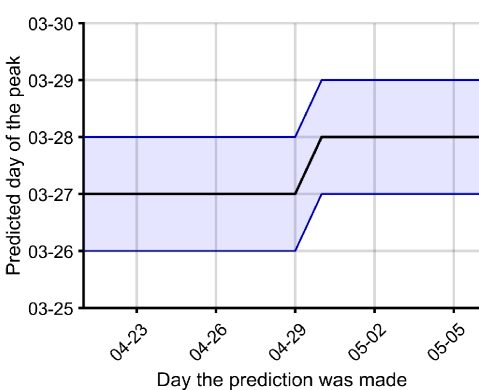
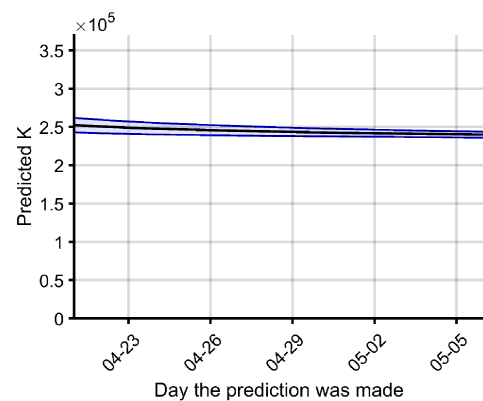
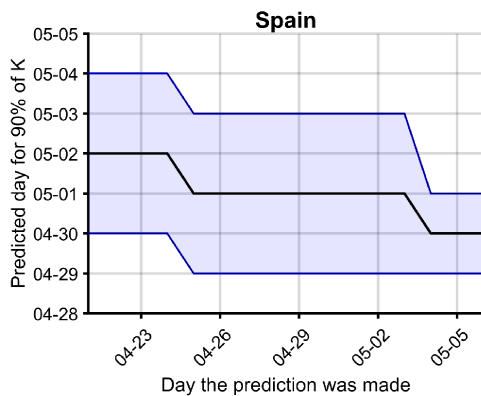
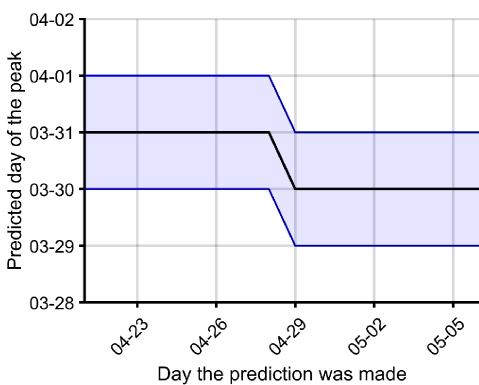
Long-term predictions, evaluated with the **whole historical series** and without weighting last 3 points. Up-left: Predictions of maximum incidences per country (total final expected attack rate per 10^5 inh.). Up-right: Predictions of maximum absolute number of cases per country (K, in log scale). Blue lines indicate current situation. Bottom-left: Time in which peak in new cases was achieved / will be achieved. Bottom-right: Time at which 90 % of K was achieved / will be achieved. Blue dotted line indicates current date.



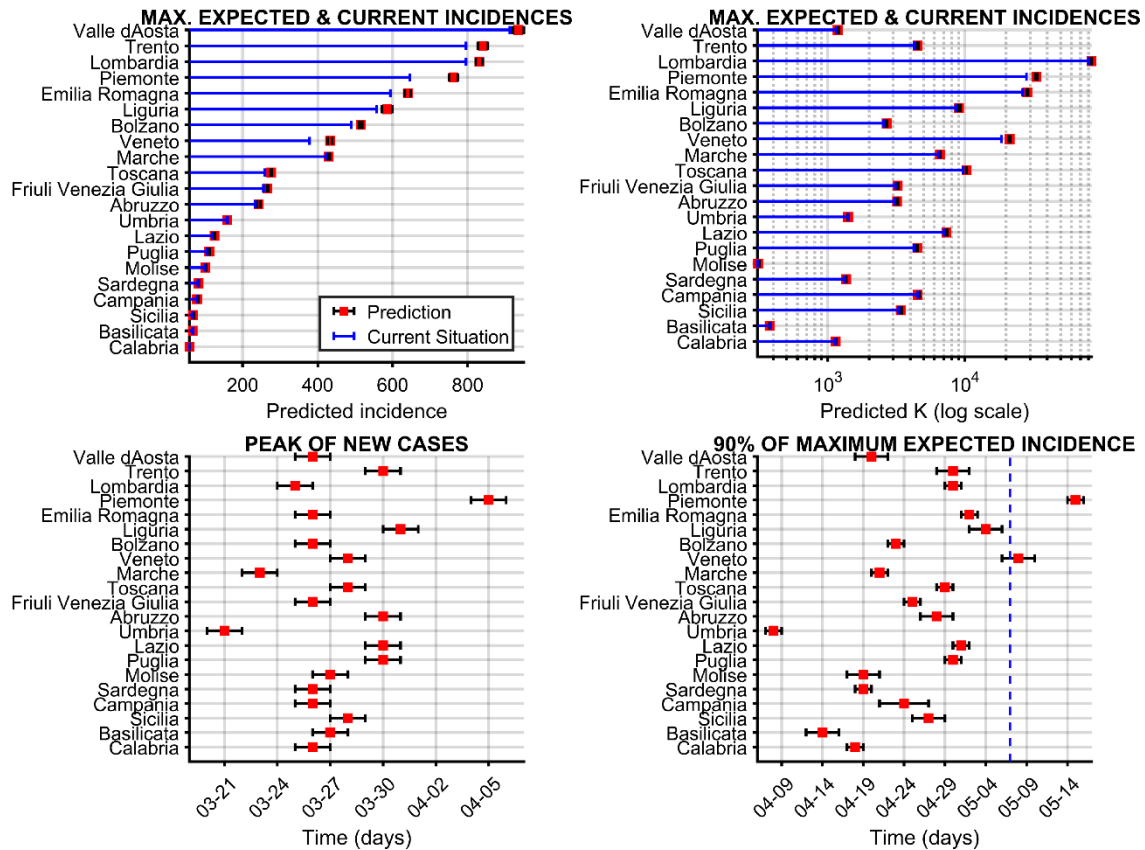
Final expected K for UE+EFTA+UK. Evolution of predicted K with time, where convergence to best estimate is seen. Last prediction is numerically shown in title.



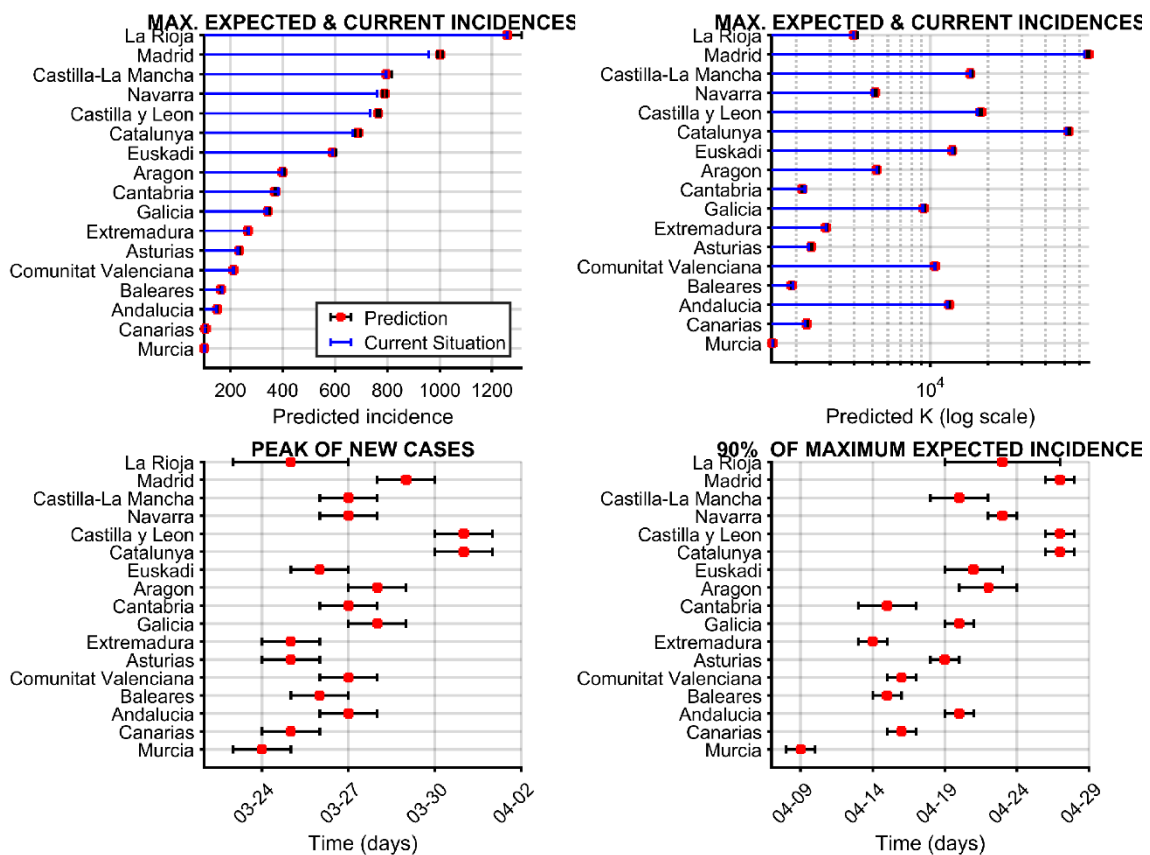
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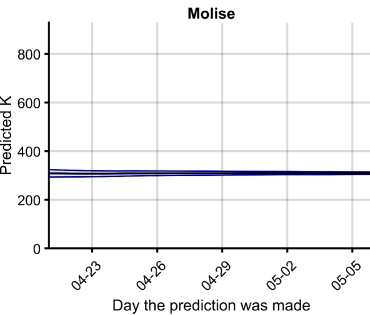
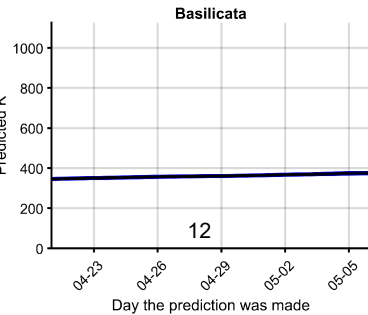
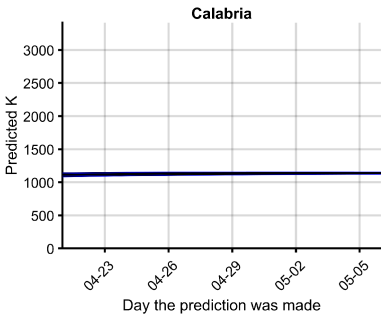
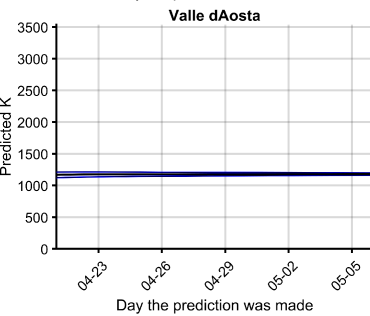
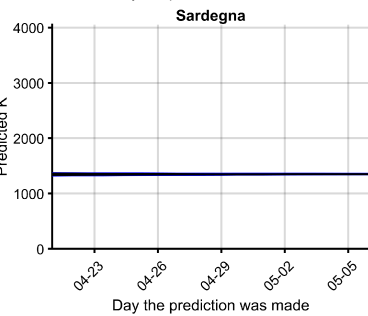
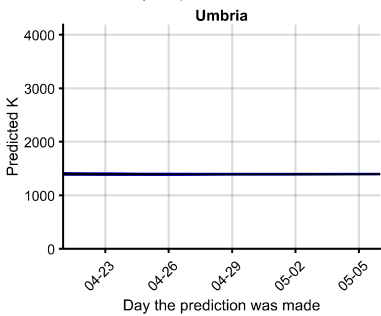
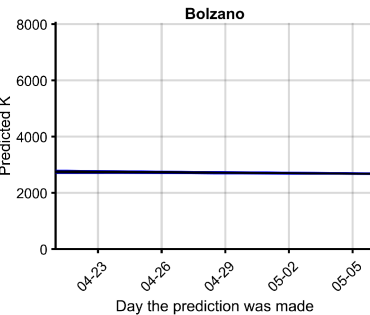
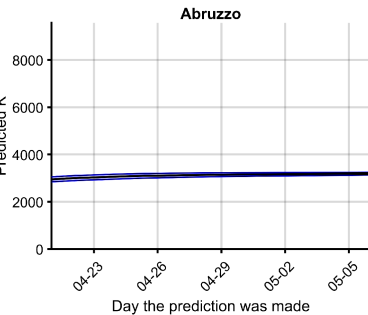
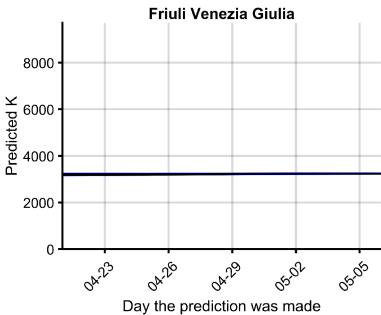
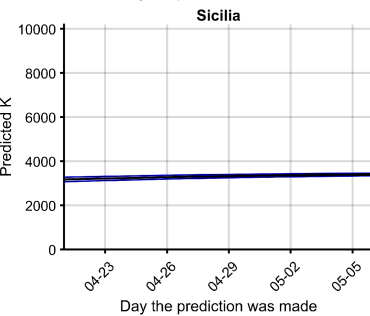
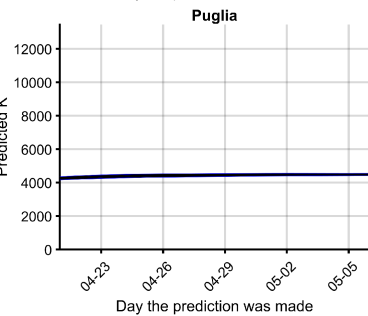
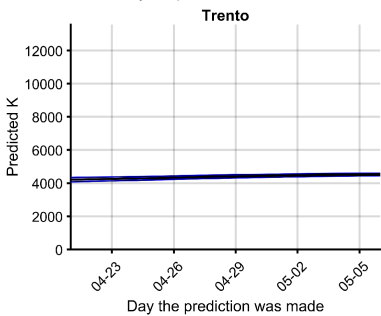
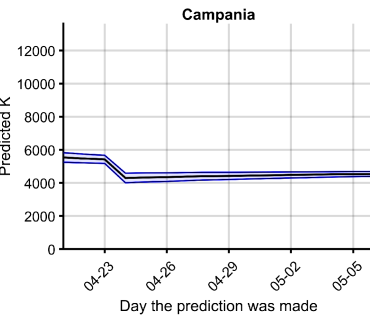
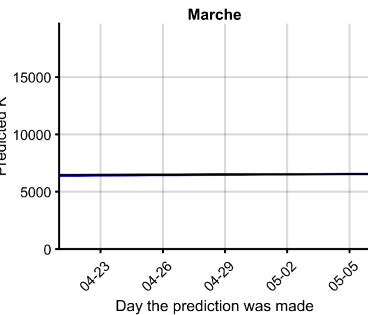
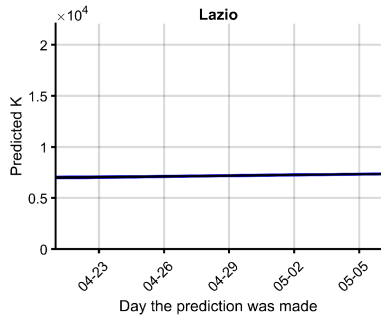
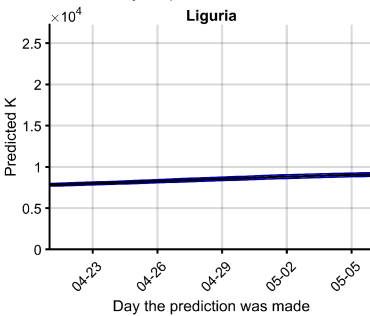
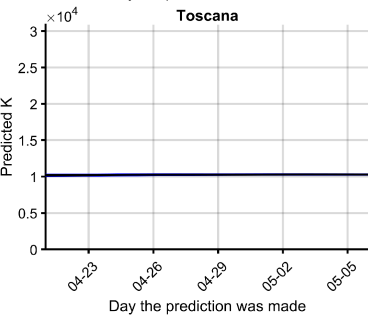
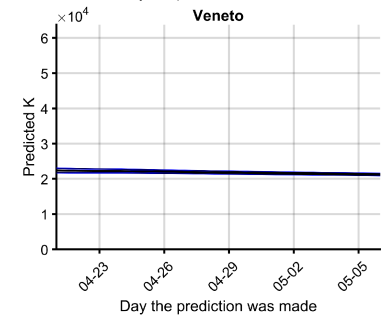
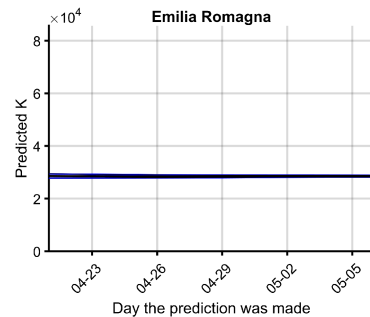
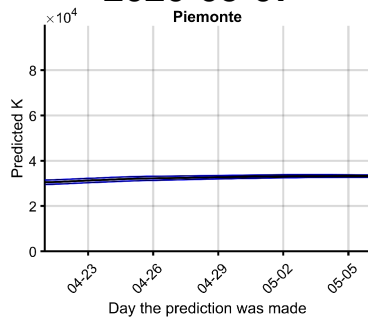
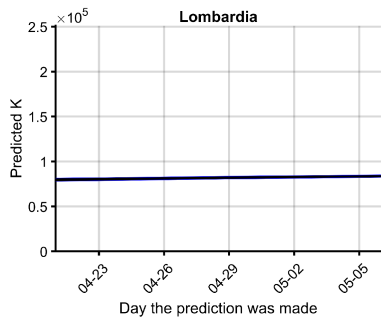
Italian regions



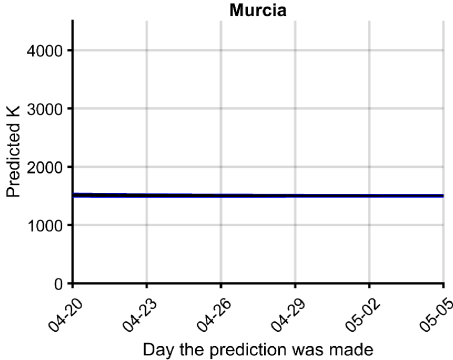
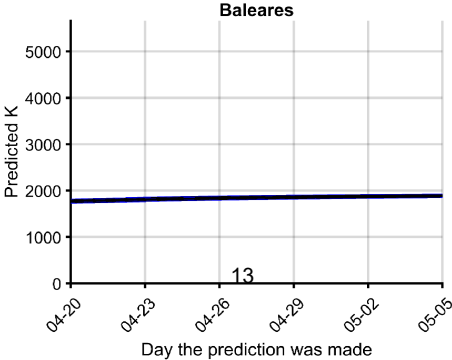
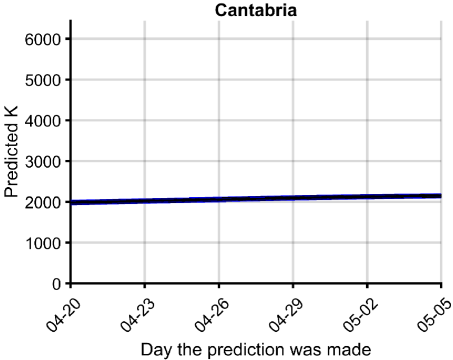
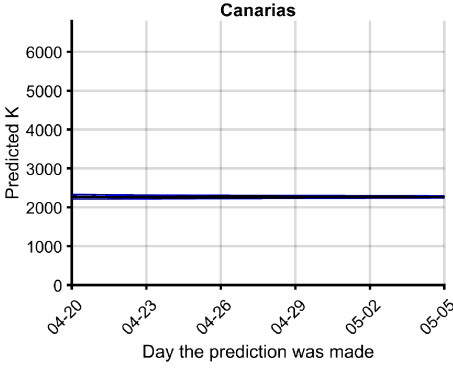
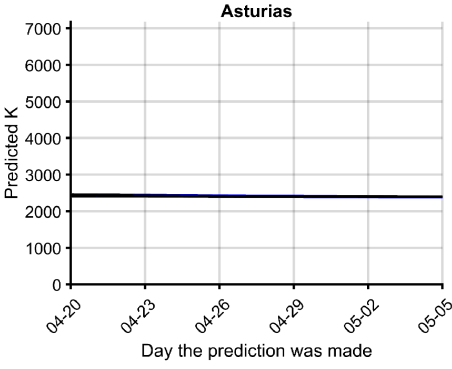
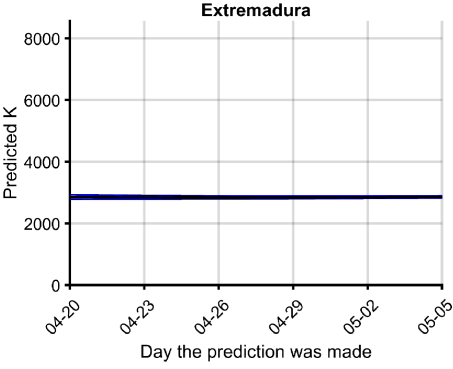
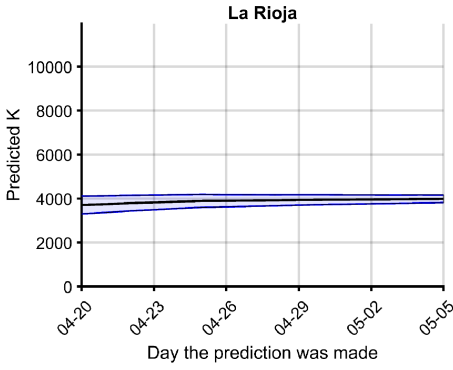
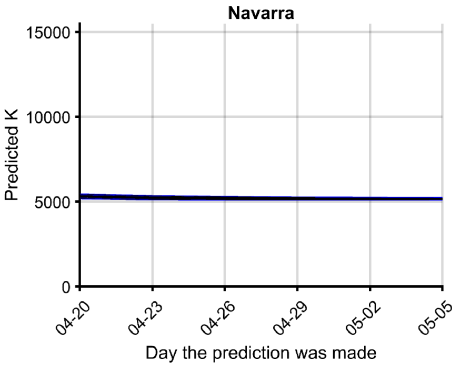
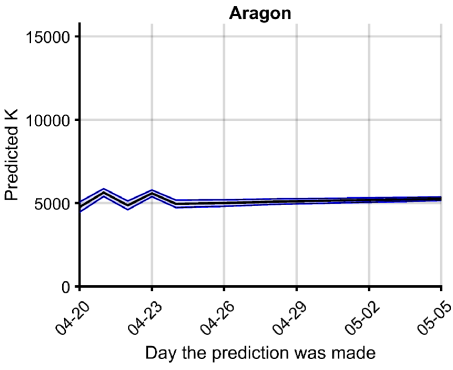
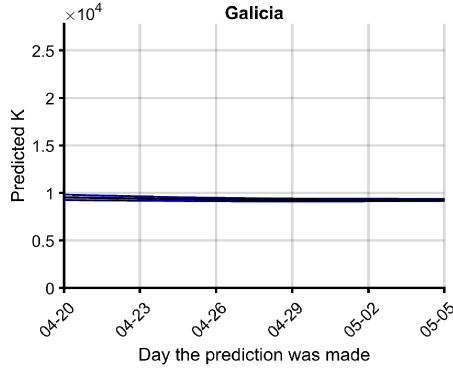
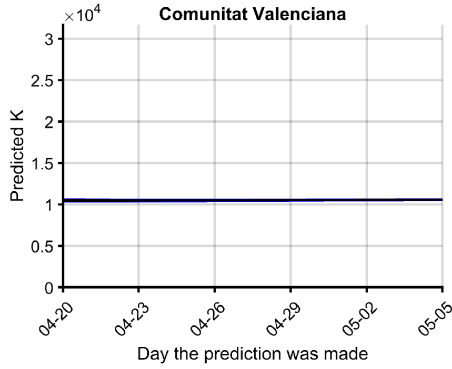
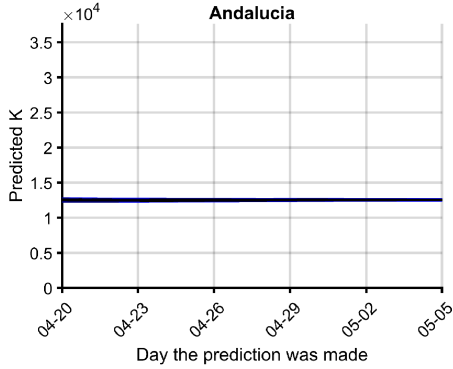
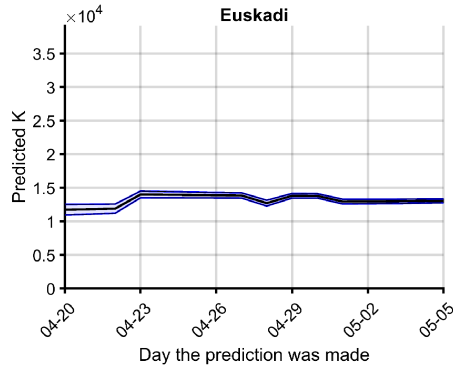
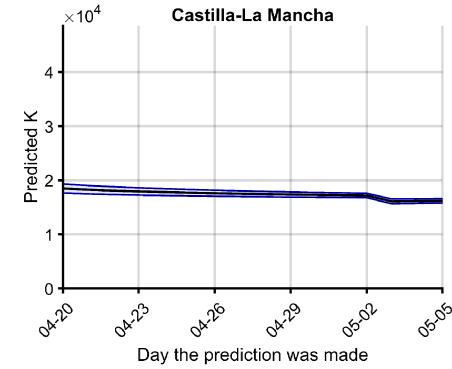
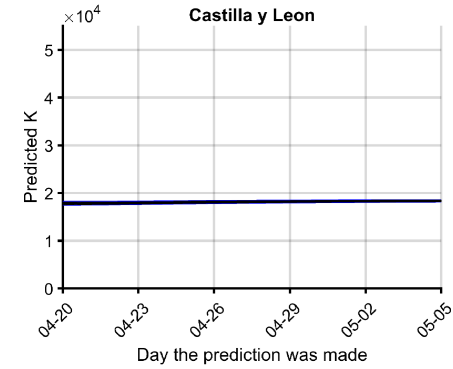
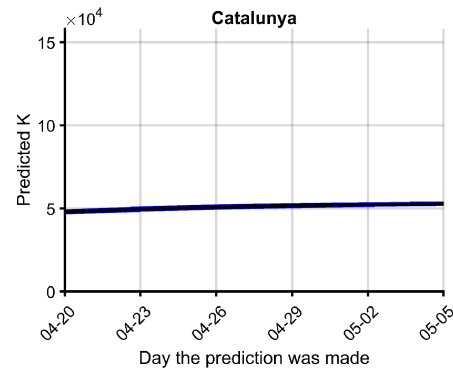
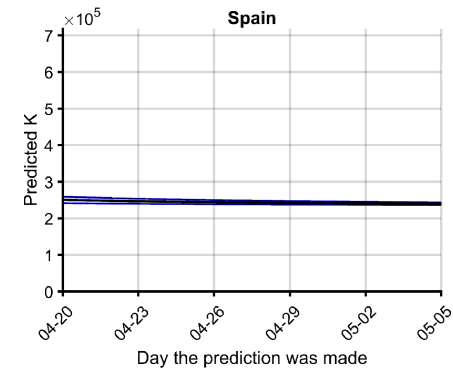
Spanish regions



2020-05-07



2020-05-06



Situation and trends in Italian and Spanish regions

Italy

Country	Reported data						Indexes		
	Cumulative cases	Attack rate / 10 ⁵ inh.	Cumulative deaths	Mortality / 10 ⁵ inh.	Active cases (last 14 days)	14-day attack rate / 10 ⁵ inh.	$\rho_7^{(1)}$	EPG _{REP} ⁽²⁾	EPG _{EST} ⁽³⁾
Lombardia	80.089	797,6	14.745	146,8	9.924	98,8	0,82	81	1.545
Piemonte	28.135	645,8	3.282	75,3	4.995	114,7	0,73	83	986
Emilia Romagna	26.487	593,9	3.766	84,4	2.764	62,0	0,72	45	651
Veneto	18.553	378,2	1.589	32,4	1.672	34,1	0,72	25	216
Toscana	9.683	259,6	915	24,5	903	24,2	0,69	17	163
Liguria	8.645	557,5	1.254	80,9	1.596	102,9	0,68	70	1.053
Lazio	7.034	119,6	543	9,2	980	16,7	0,81	13	108
Marche	6.452	423,0	948	62,2	500	32,8	0,83	27	402
Campania	4.541	78,3	379	6,5	303	5,2	0,75	4	34
Trento	4.283	399,4	438	40,8	556	51,9	0,54	28	582
Puglia	4.245	105,4	441	10,9	406	10,1	0,83	8	96
Sicilia	3.288	65,8	251	5,0	362	7,2	0,63	5	36
Friuli Venezia Giulia	3.107	255,7	308	25,3	249	20,5	0,55	11	116
Abruzzo	3.072	234,2	348	26,5	287	21,9	0,99	22	263
Bolzano	2.552	2.375,4	286	266,2	117	108,9	0,52	56	129
Umbria	1.405	159,3	70	7,9	43	4,9	1,09	5	NA
Sardegna	1.324	80,8	119	7,3	70	4,3	0,67	3	27
Valle d'Aosta	1.150	915,6	139	110,7	54	43,0	0,72	31	375
Calabria	1.125	57,8	89	4,6	56	2,9	0,61	2	NA
Basilicata	383	68,0	26	4,6	27	4,8	NA	NA	NA
Molise	305	99,8	22	7,2	21	6,9	0,61	4	NA

Scale									
Worst	Worst	Worst	Worst	Worst	Worst	Worst	2,0	200	2000
Best	Best	Best	Best	Best	Best	Best	0,0	0	0

Spain

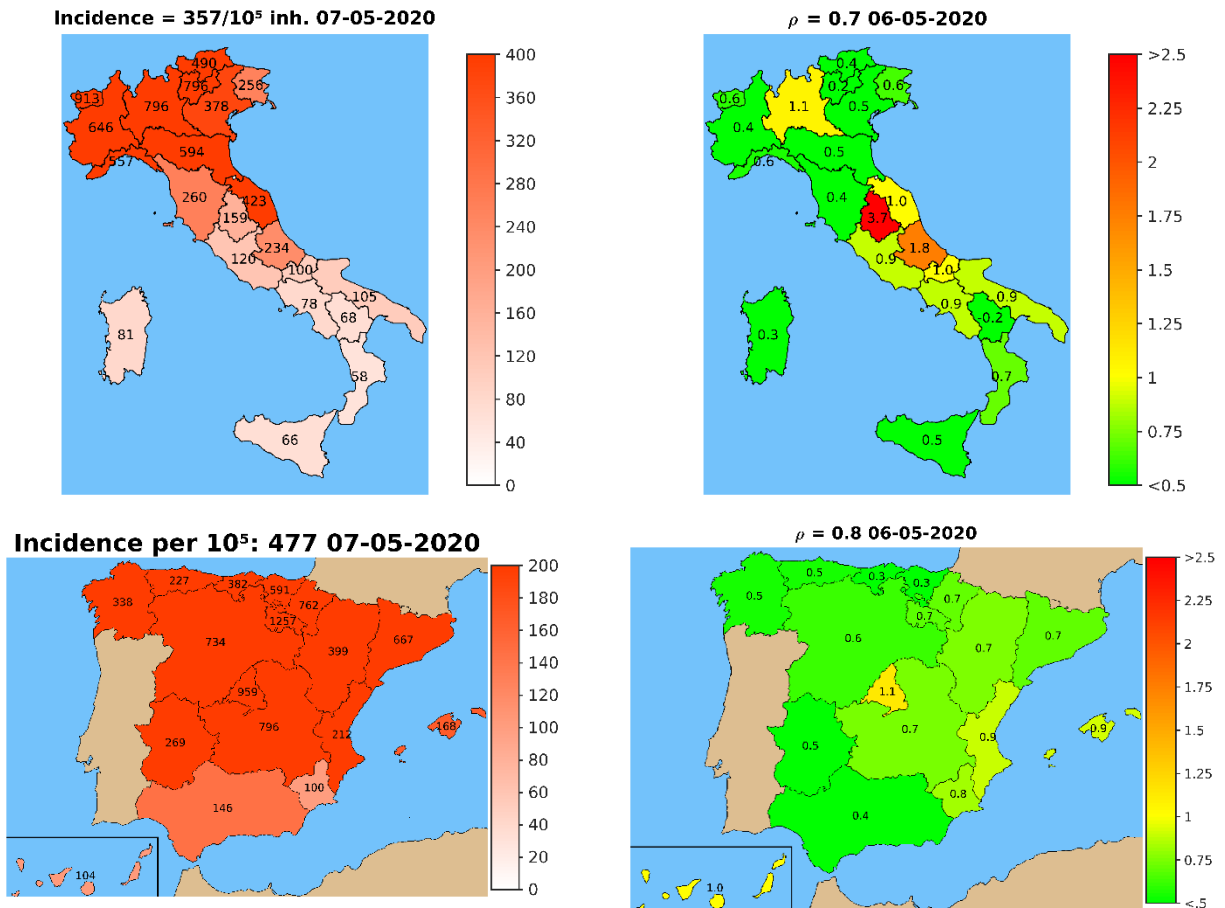
Autonomous regions	Reported data						Indexes		
	Cumulative cases	Attack rate /10 ⁵ inh.	Cumulated deaths	Mortality rate /10 ⁵ inh.	Active cases (last 14 days)	14-day attack rate /10 ⁵ inh.	$\rho_7^{(1)}$	EPG _{REP} ⁽²⁾	EPG _{EST} ⁽³⁾
Madrid	63.870	961,8	8.504	128,1	6.776	102,0	0,82	84	1.130
Catalunya	51.190	676,7	5.394	71,3	6.298	83,3	0,64	53	581
Castilla y Leon	17.625	731,9	1.864	77,4	2.115	87,8	0,63	55	607
Castilla-La Mancha	16.184	795,1	2.677	131,5	1.056	51,9	0,7	36	571
Euskadi	13.041	598,7	1.383	63,5	1.252	57,5	0,54	31	329
Andalucía	12.268	145,6	1.294	15,4	865	10,3	0,38	4	42
Comunitat Valenciana	10.592	212,9	1.303	26,2	723	14,5	0,76	11	136
Galicia	9.134	338,3	586	21,7	681	25,2	1,56	39	269
Aragon	5.258	398,1	800	60,6	425	32,2	0,78	25	409
Navarra	4.983	766,7	480	73,9	406	62,5	0,68	43	441
La Rioja	3.986	1.271,1	338	107,8	245	78,1	0,54	43	356
Extremadura	2.877	270,0	467	43,8	162	15,2	1,36	21	358
Asturias	2.326	227,5	292	28,6	97	9,5	0,94	9	121
Canarias	2.235	101,3	144	6,5	122	5,5	0,56	3	20
Cantabria	2.220	381,7	200	34,4	197	33,9	0,54	18	169
Baleares	1.929	162,4	201	16,9	122	10,3	0,65	7	75
Murcia	1.501	100,9	137	9,2	41	2,8	0,85	2	22
Melilla	119	140,5	2	2,4	13	15,3	NA	NA	NA
Ceuta	109	128,5	4	4,7	9	10,6	NA	NA	NA

Scale									
Worst	Worst	Worst	Worst	Worst	Worst	Worst	2,0	200	2000
Best	Best	Best	Best	Best	Best	Best	0,0	0	0

⁽¹⁾ ρ_3 is the average of 7 consecutive ρ , but can still fluctuate. ⁽²⁾ EPG stands for Effective Growth Potential. EPG_{REP} is obtained by multiplying attack rate of last 14 days per 10⁵ inhabitants (i.e. density of cases) by ρ_3 (a value related with effective reproduction number and that, therefore, determines the dynamics for subsequent days). EPG_{EST} is obtained by multiplying estimated real attack rate of last 14 days per 10⁵ inhabitants by ρ_3 .

Maps of Italian and Spanish regions

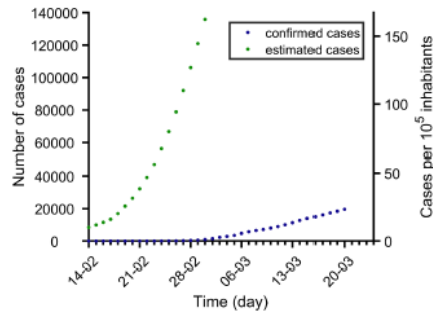
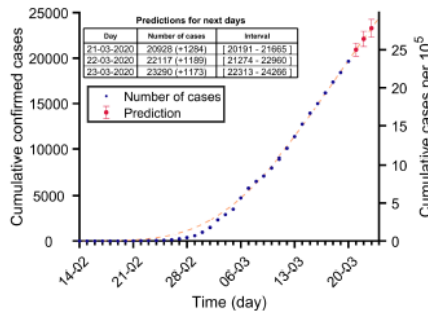
Cumulative incidence and spreading rate (ρ) in Italian and Spanish regions.



Legend: Countries' reports details

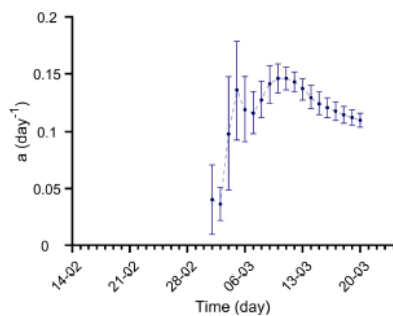
Iran 20-03-2020. Population: 83.7M. Current cumulated incidence: $23/10^5$

Confirmed cases:
data (blue),
model fitted
(dashed line),
predictions (red
points and table)

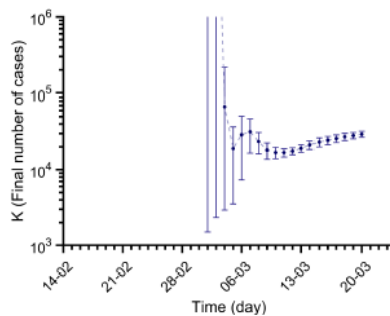


Estimated
cases using
death rate (see
Methods)

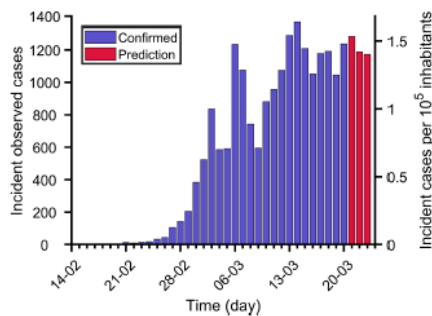
Fitted a value
using points
prior to each
date



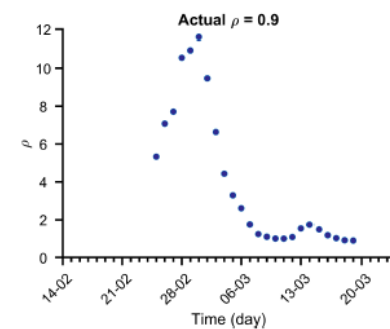
Fitted K value
using points
prior to each
date



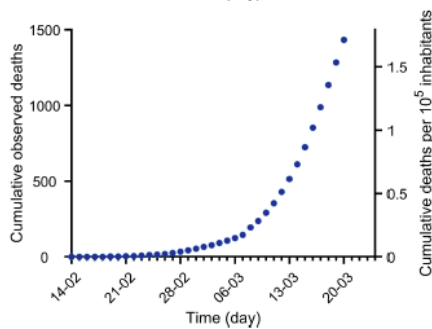
Reported
and
predicted
new cases



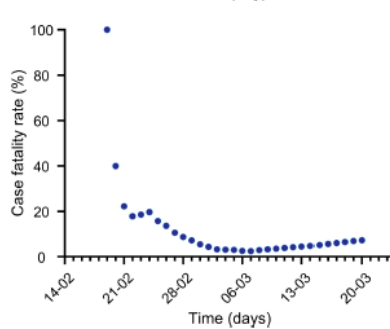
Evolution of ρ , a
parameter related
with Reproduction
number (see
Methods)



Reported
deaths



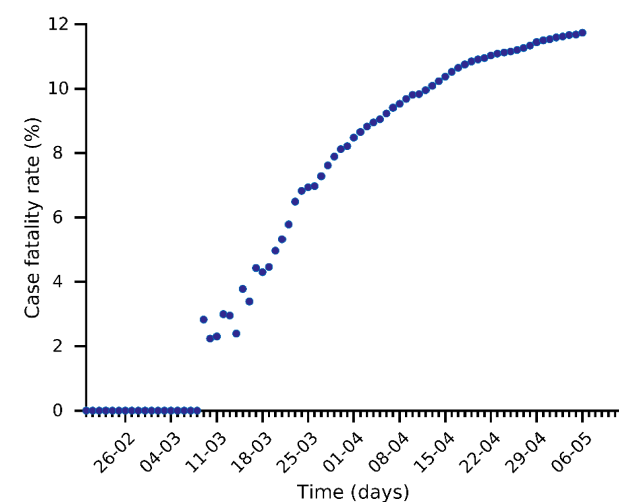
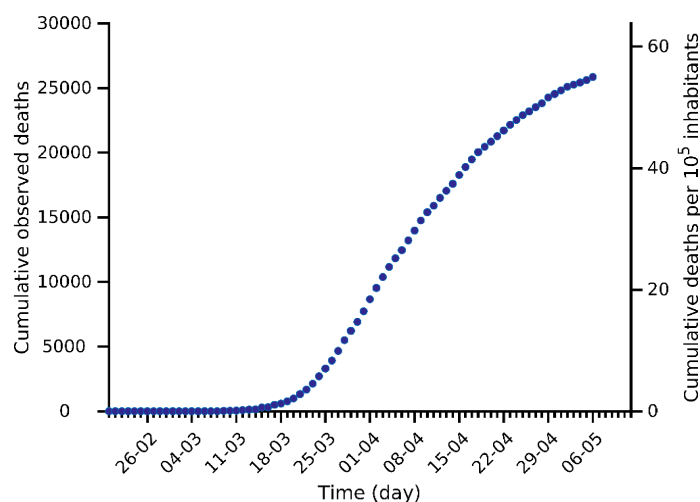
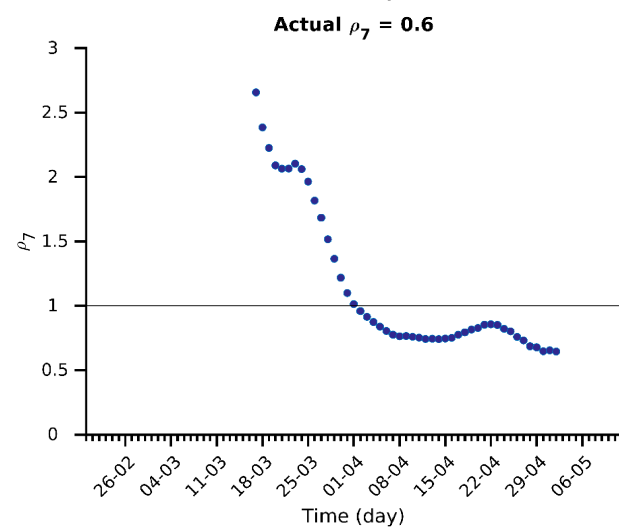
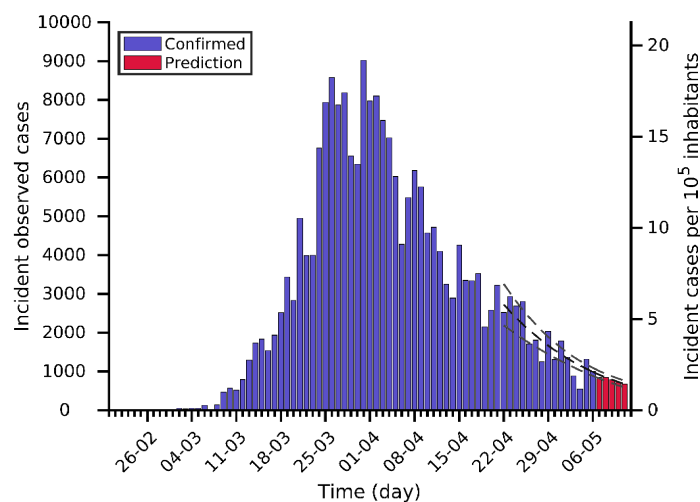
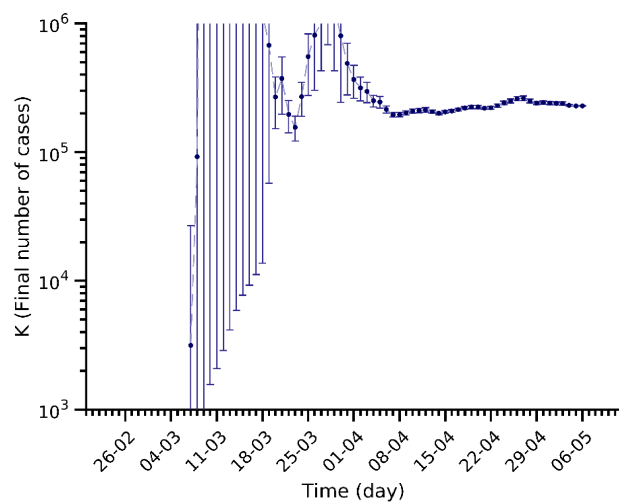
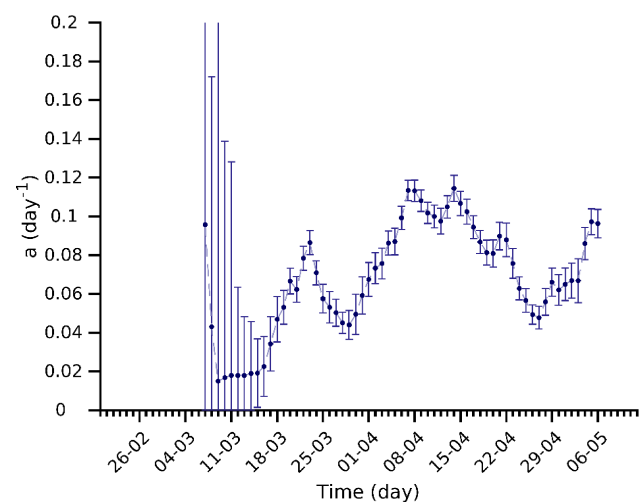
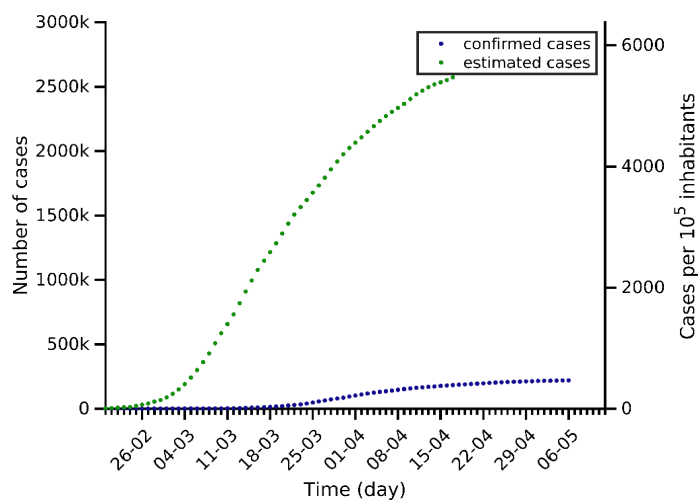
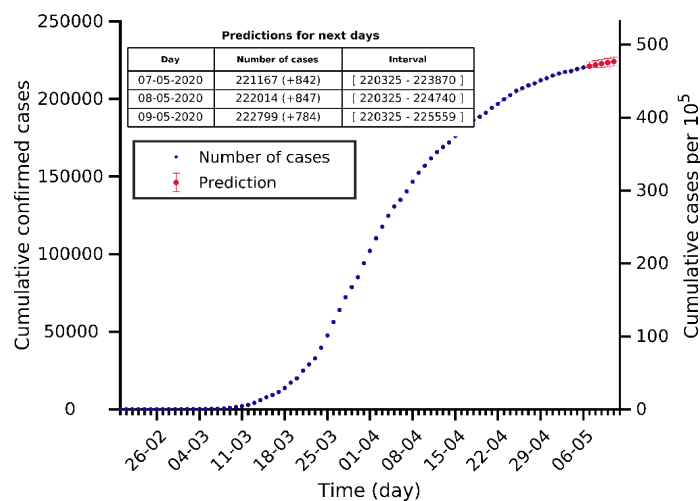
Deaths /
cumulated
reported cases



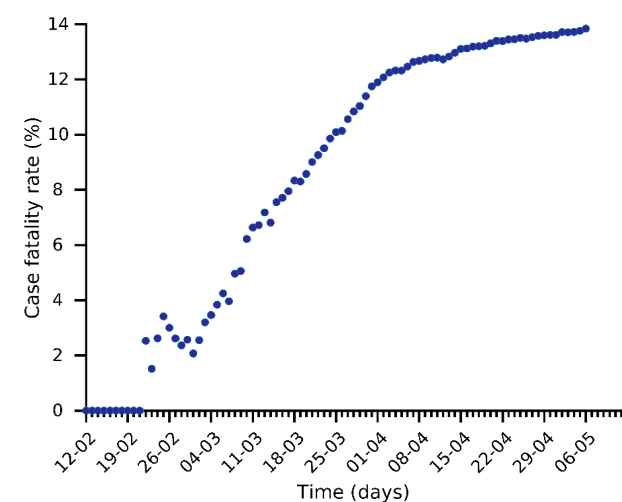
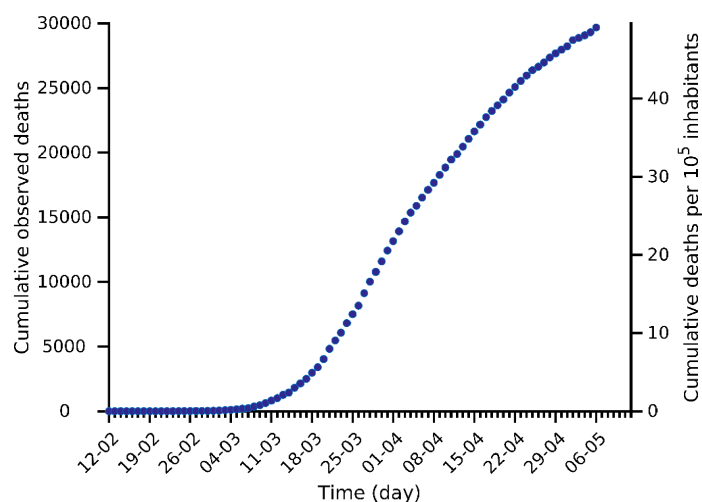
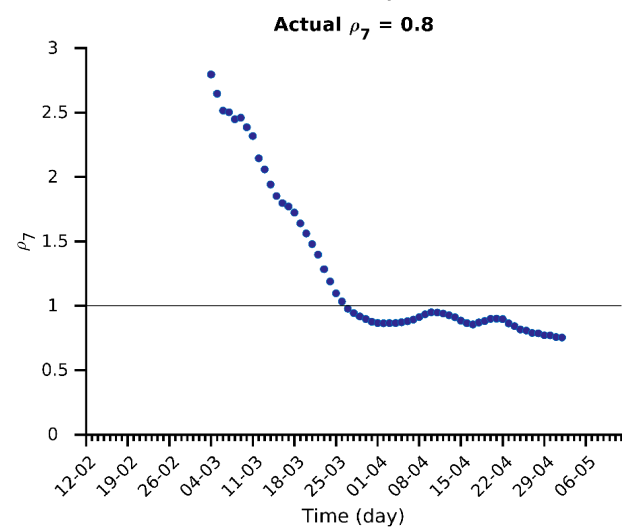
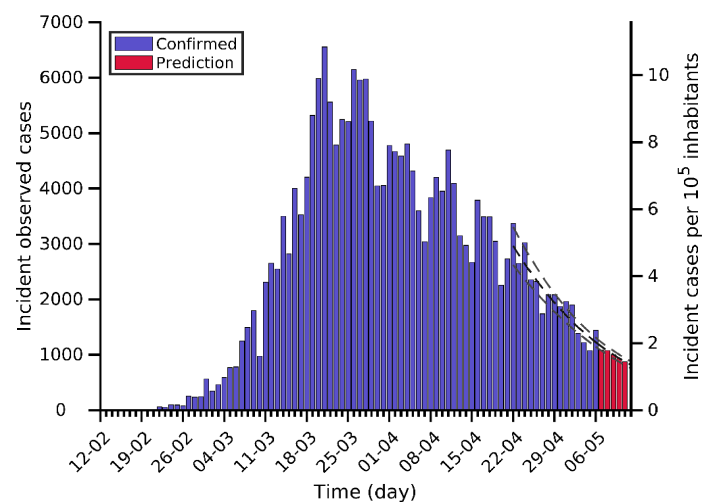
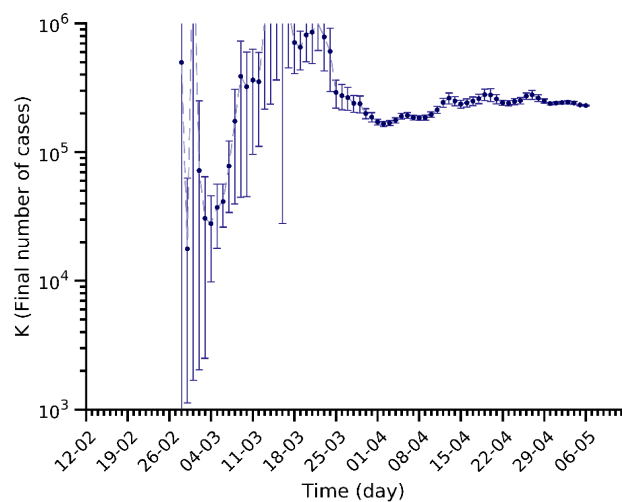
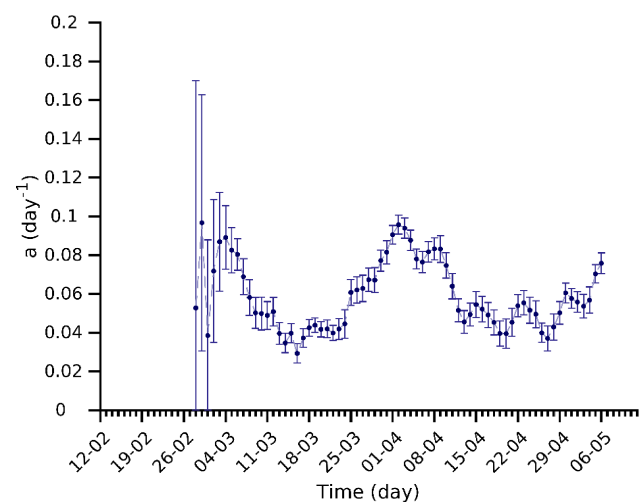
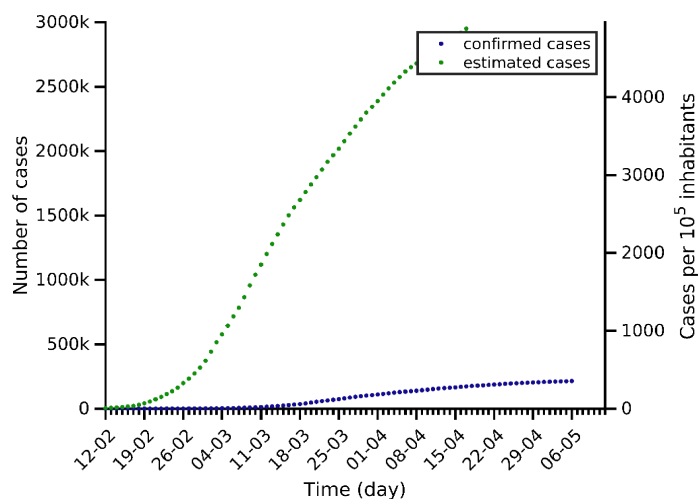
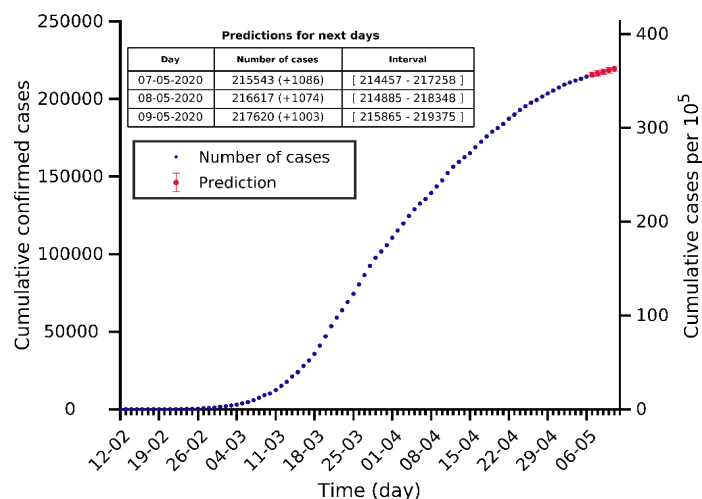
(1) Analysis and prediction of COVID-19 for EU+EFTA+UK

Data obtained from <https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases>

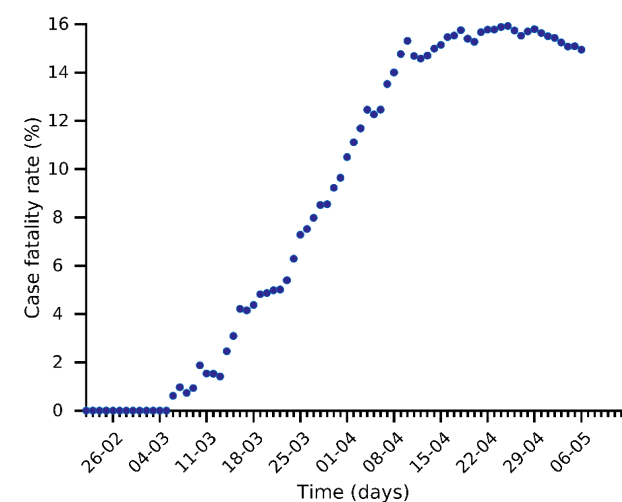
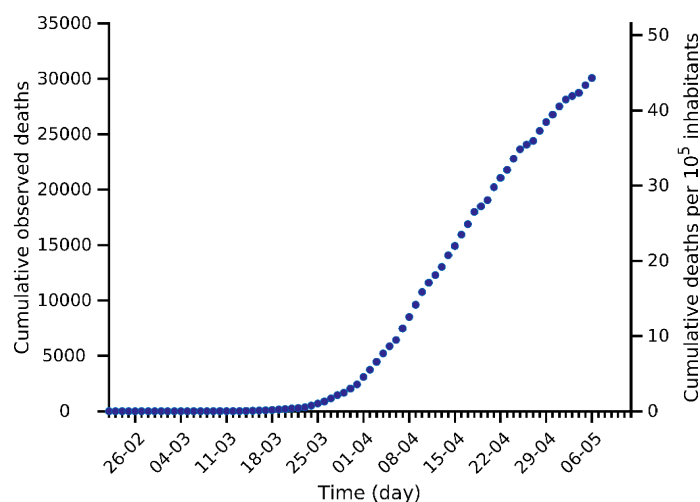
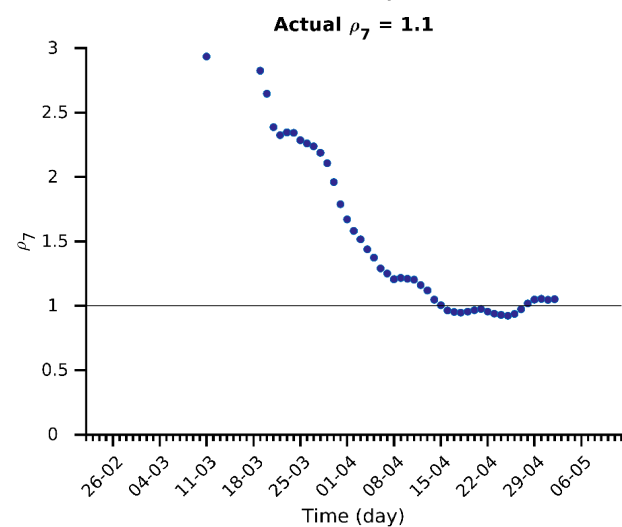
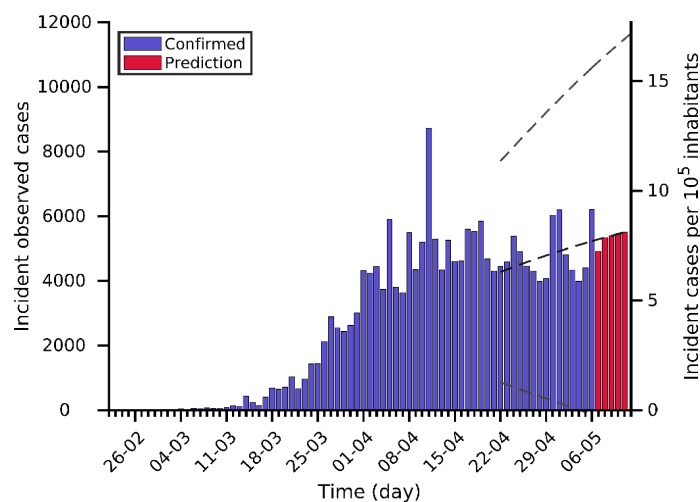
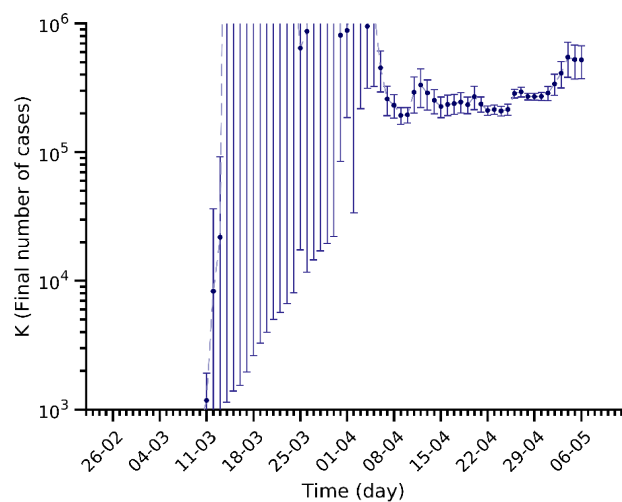
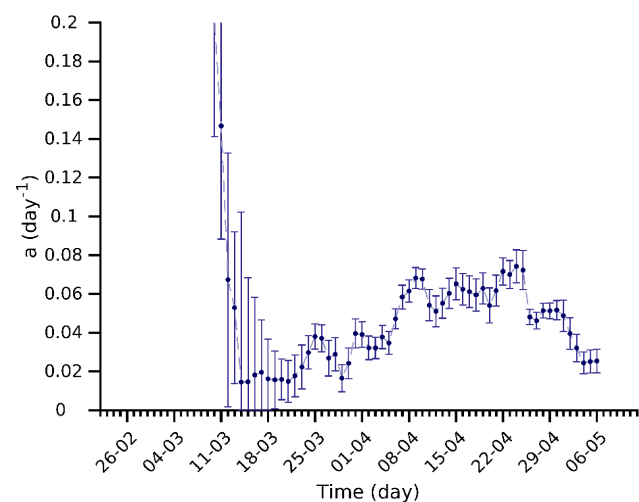
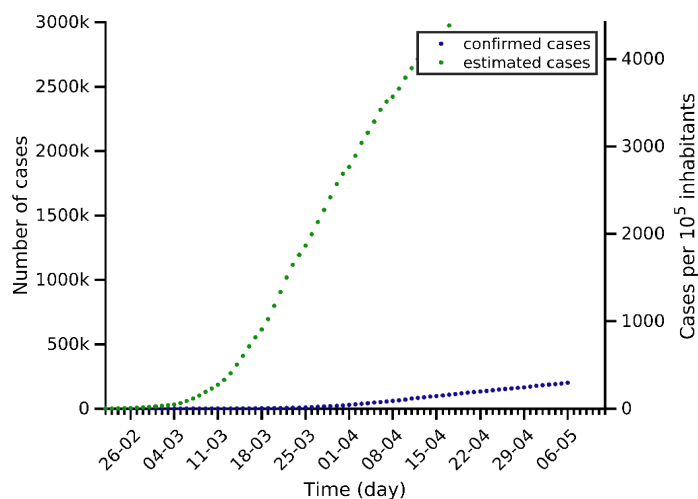
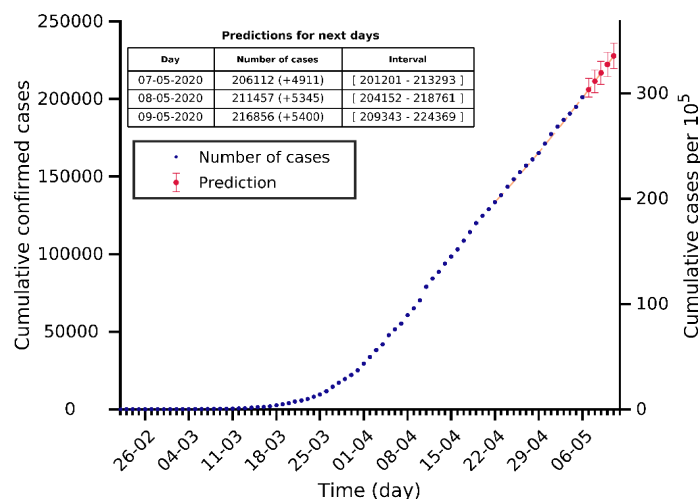
Spain 06-05-2020. Population: 47.0M. Current cumulated incidence: 469/10⁵



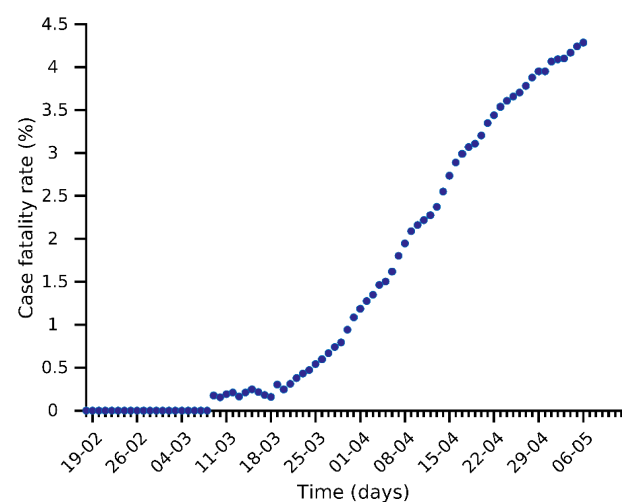
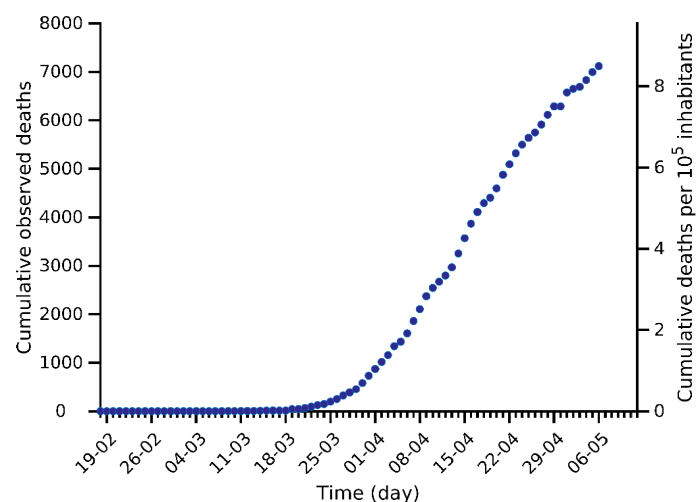
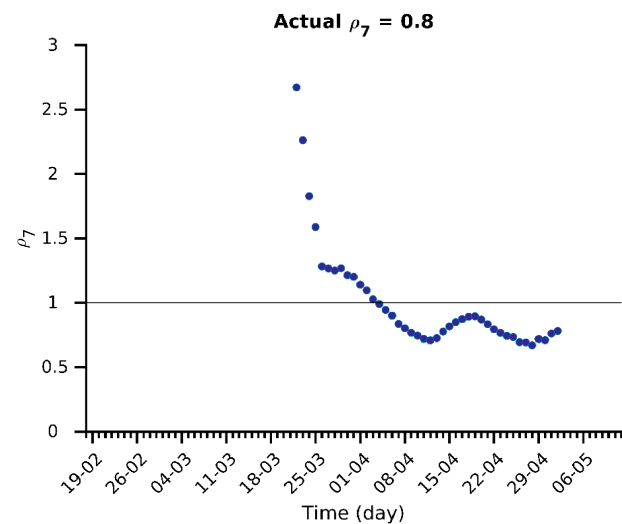
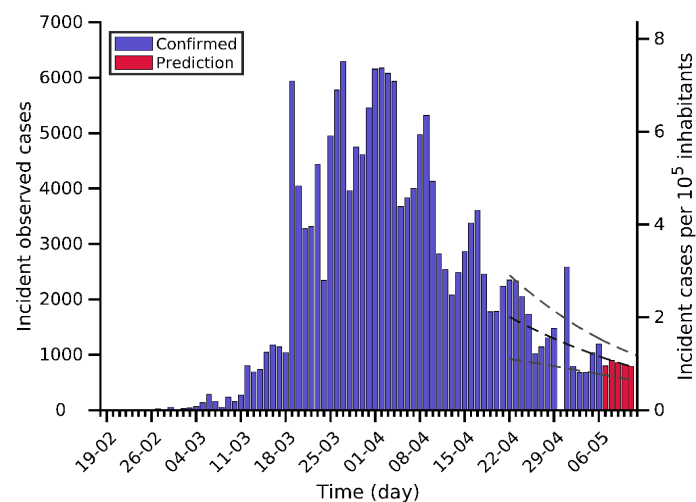
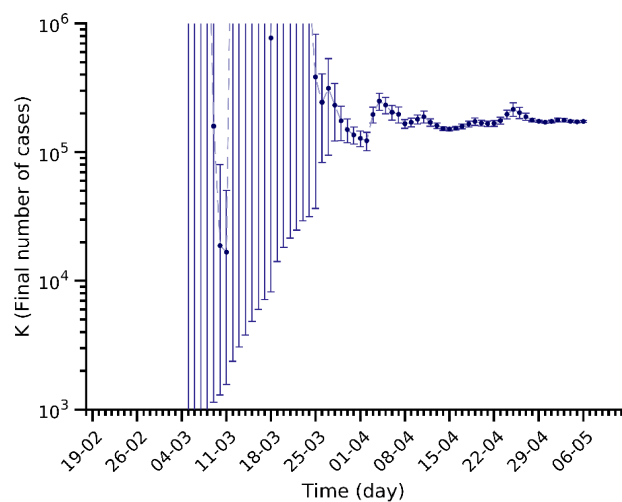
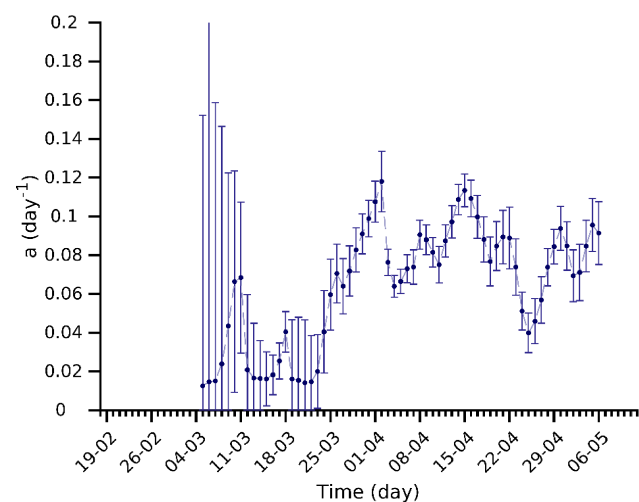
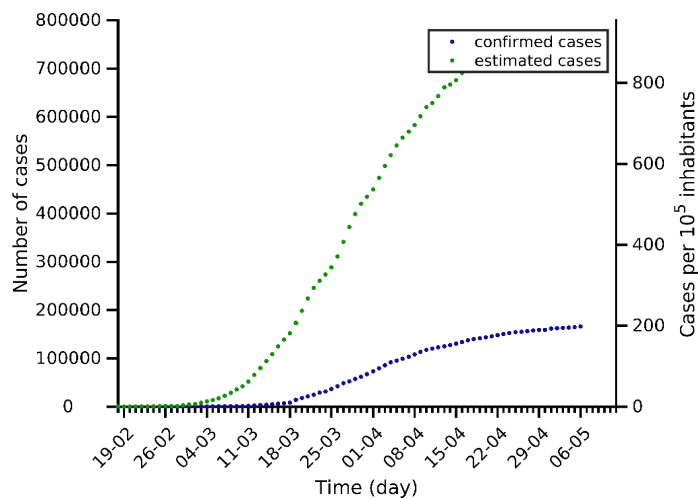
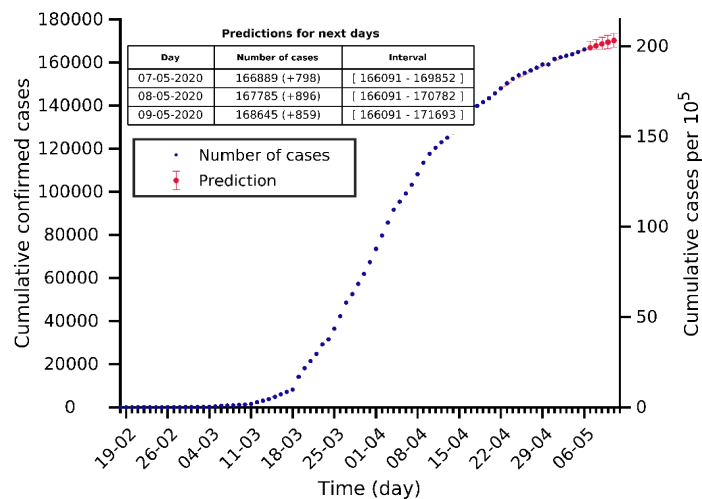
Italy 06-05-2020. Population: 60.5M. Current cumulated incidence: 355/10⁵



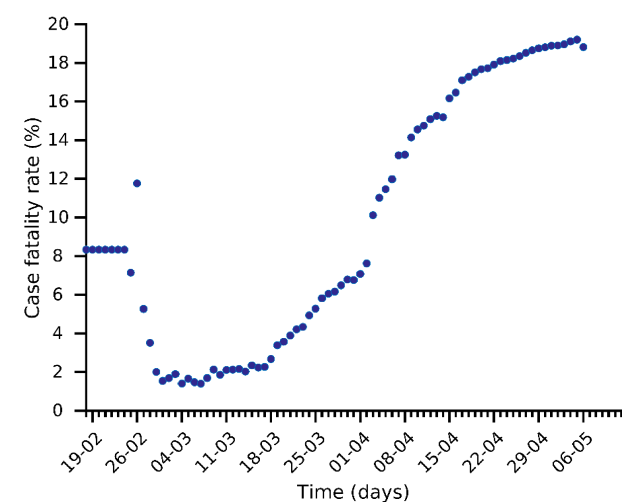
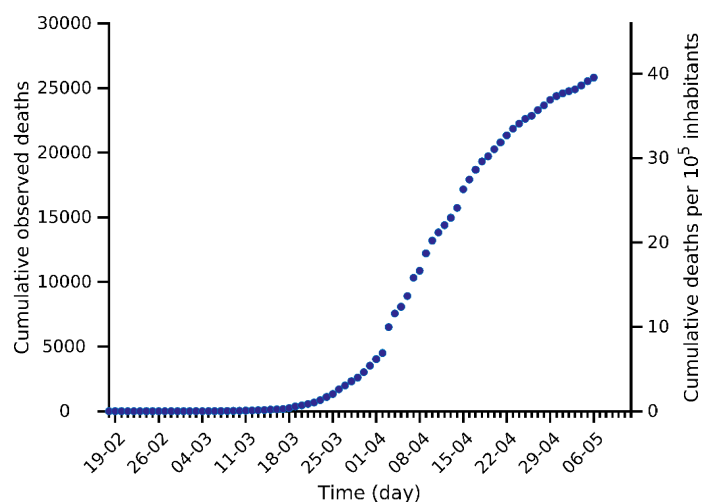
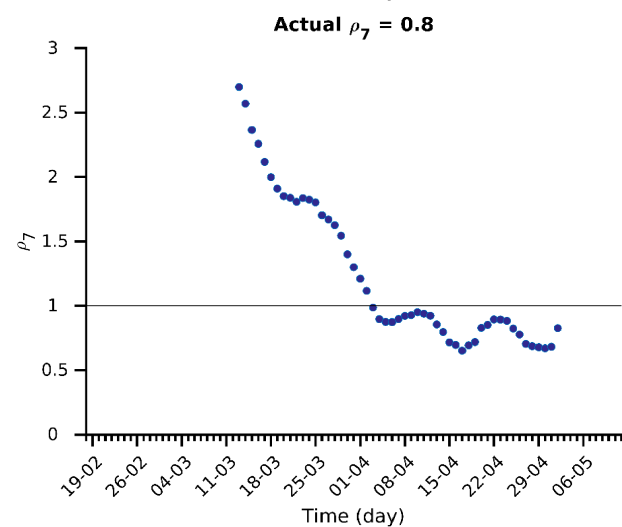
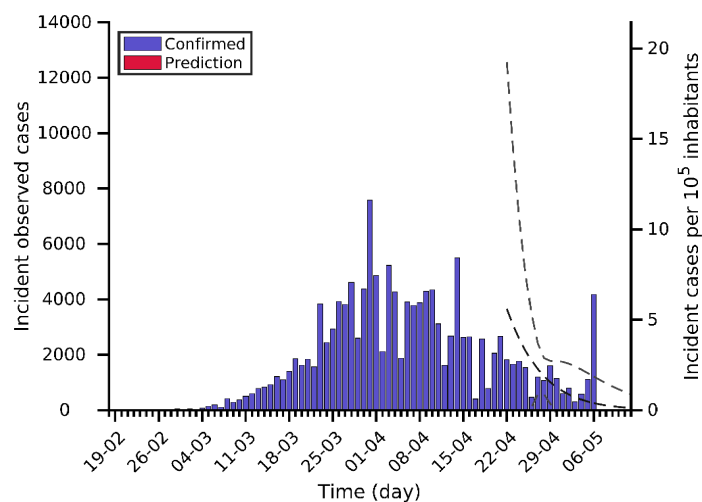
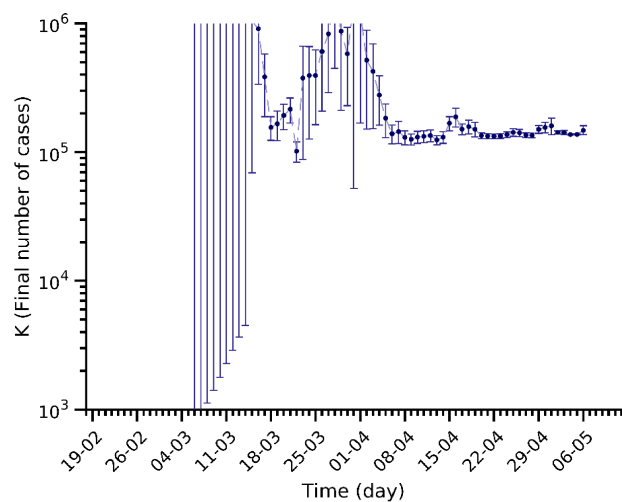
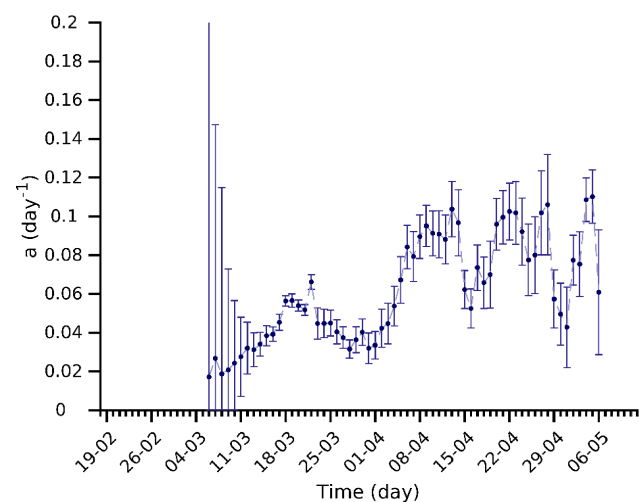
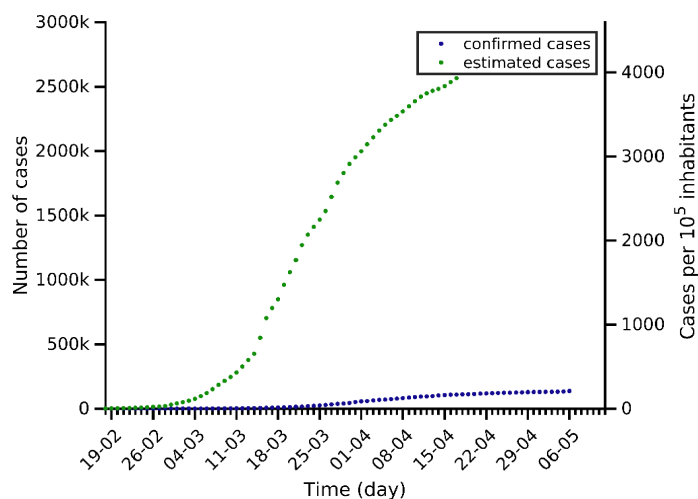
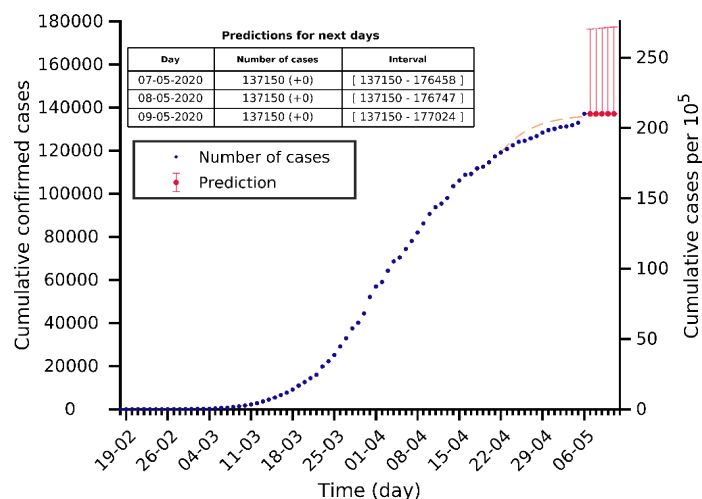
UK 06-05-2020. Population: 67.9M. Current cumulated incidence: 296/10⁵

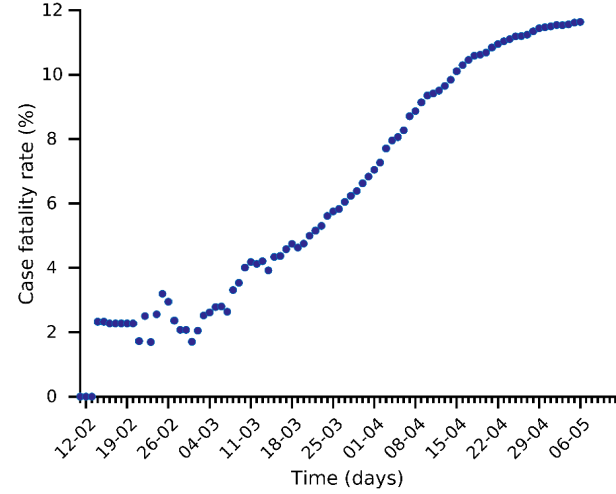
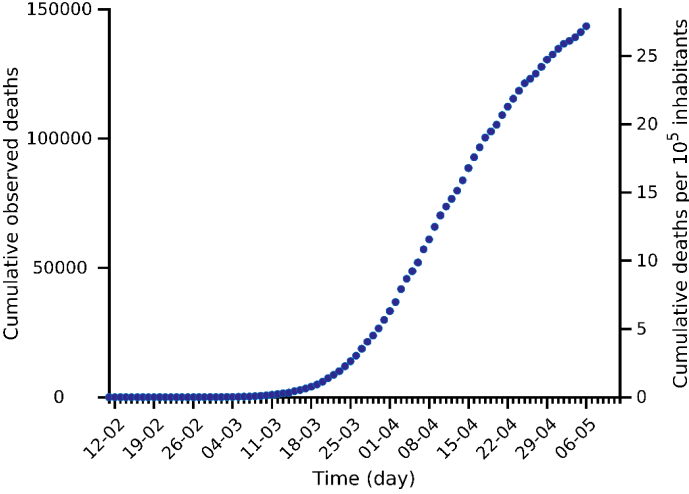
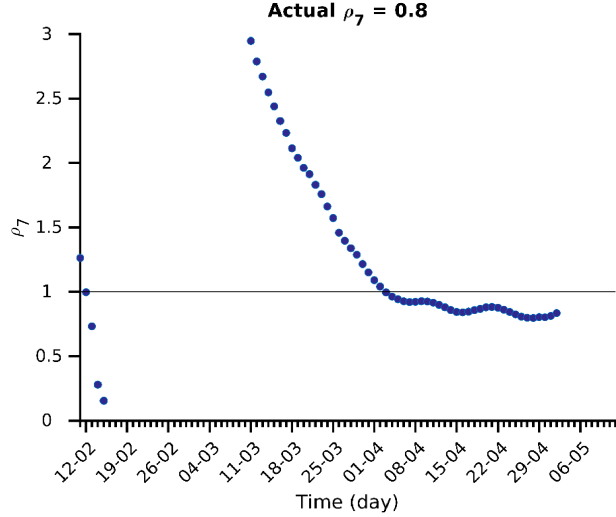
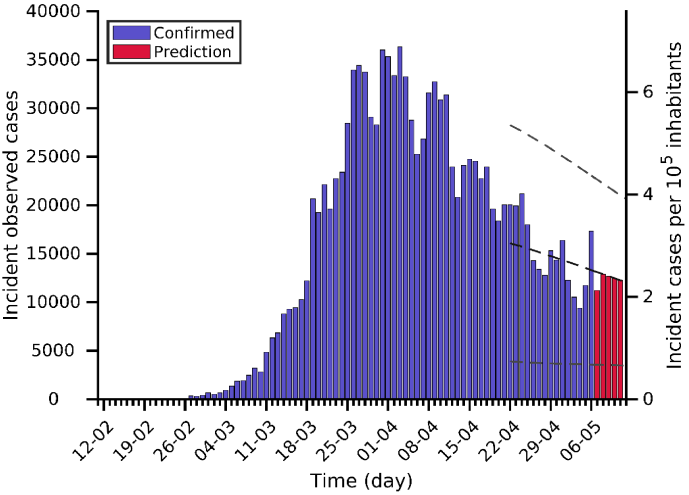
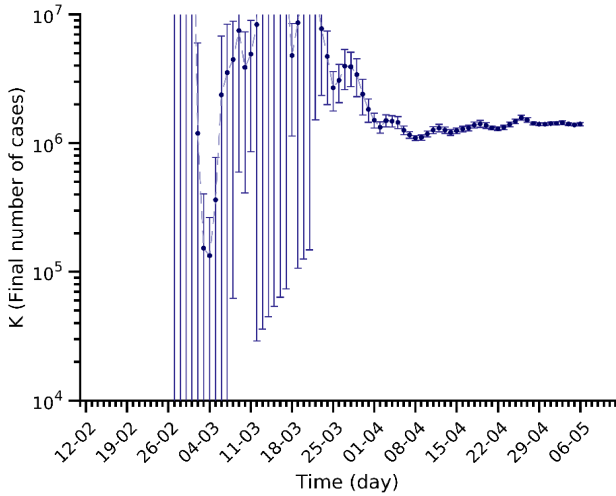
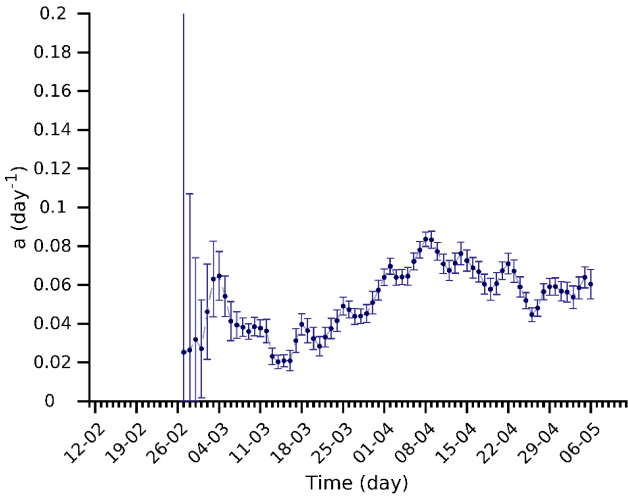
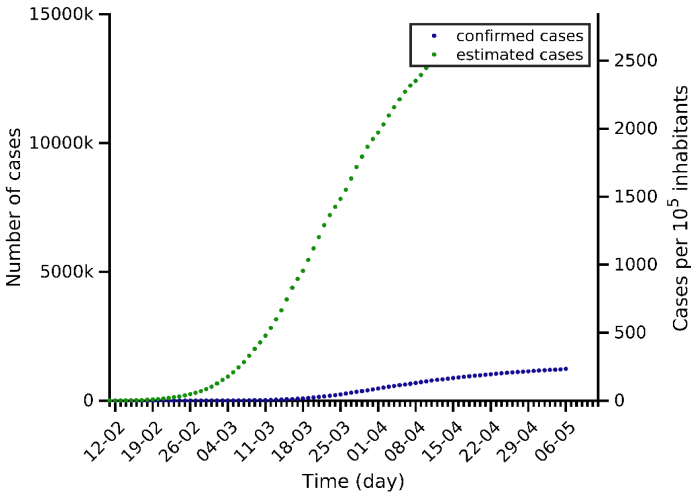
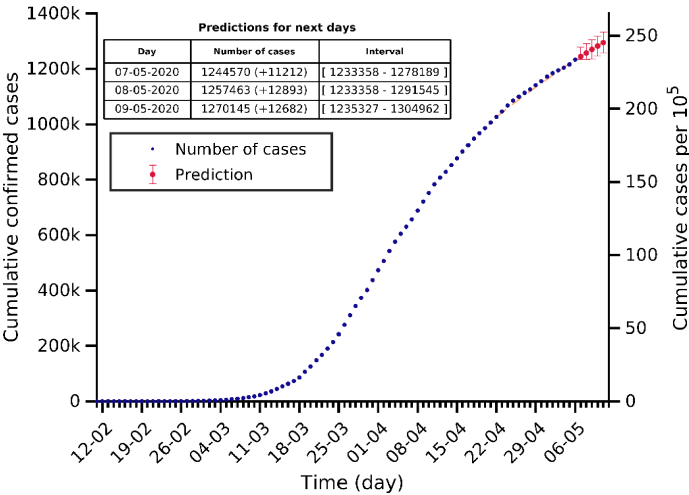


Germany 06-05-2020. Population: 83.8M. Current cumulated incidence: 198/10⁵

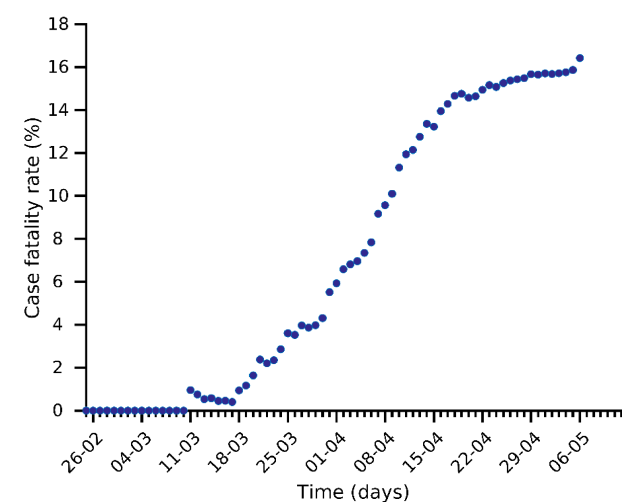
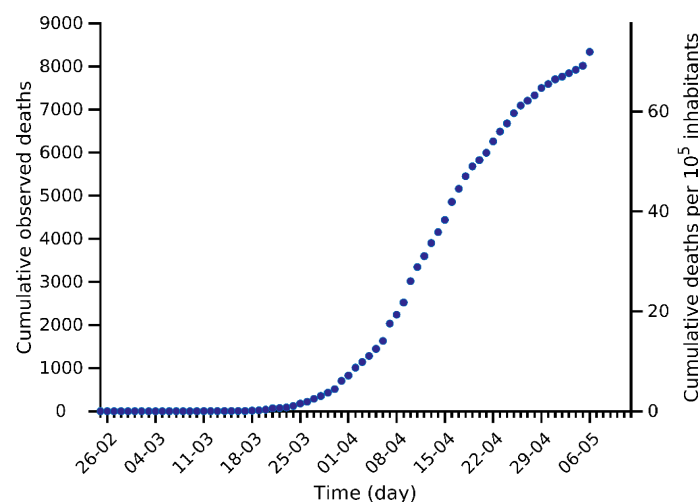
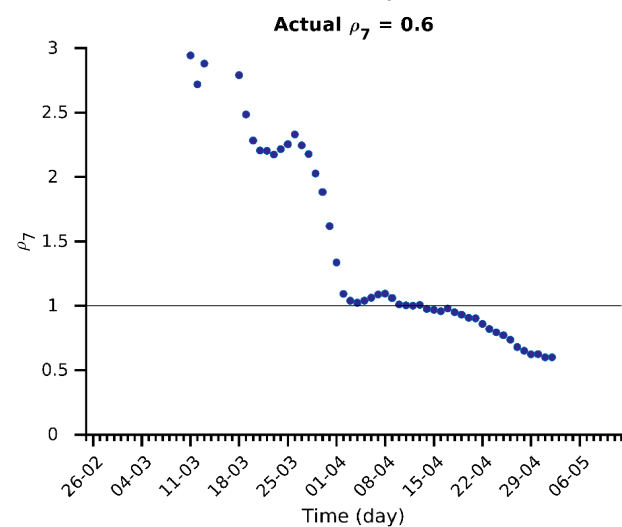
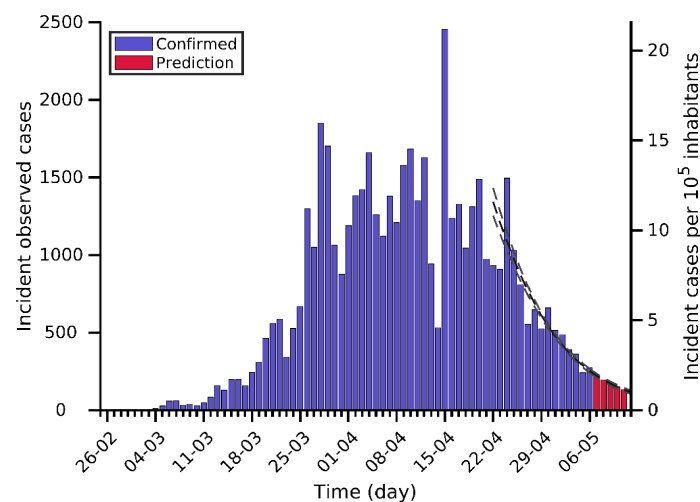
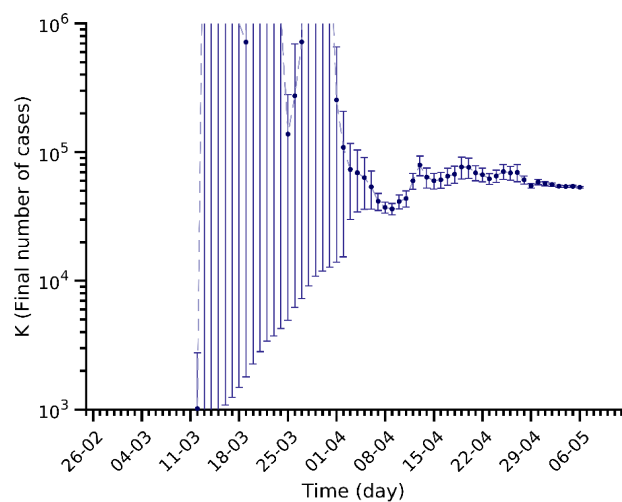
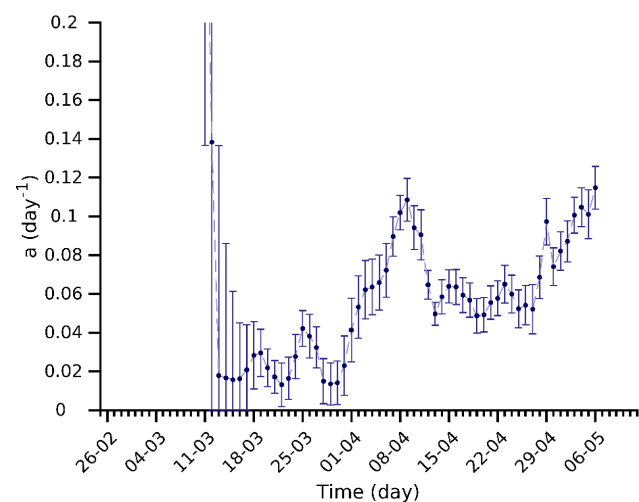
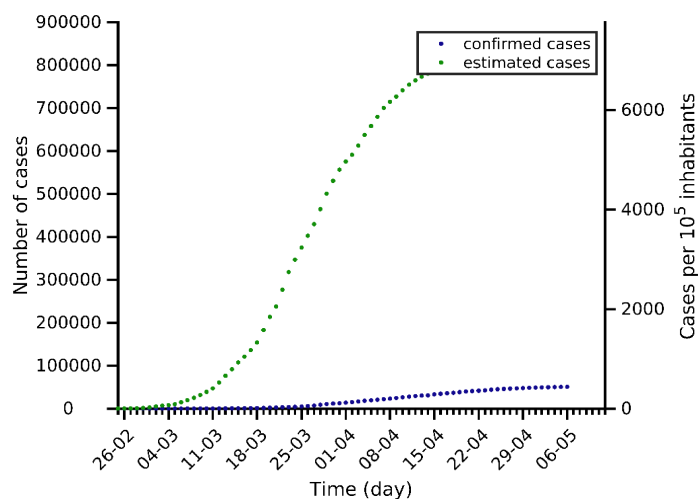
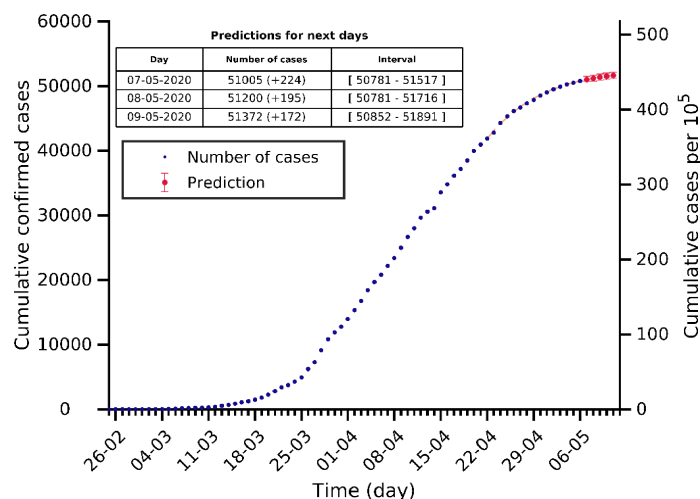


France 06-05-2020. Population: 65.3M. Current cumulated incidence: 210/10⁵

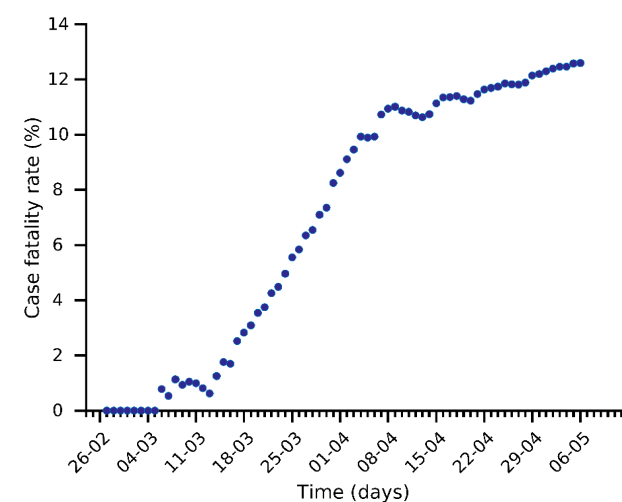
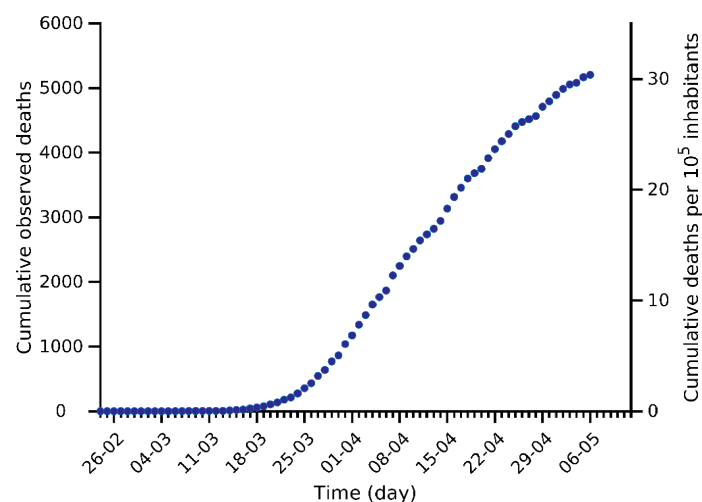
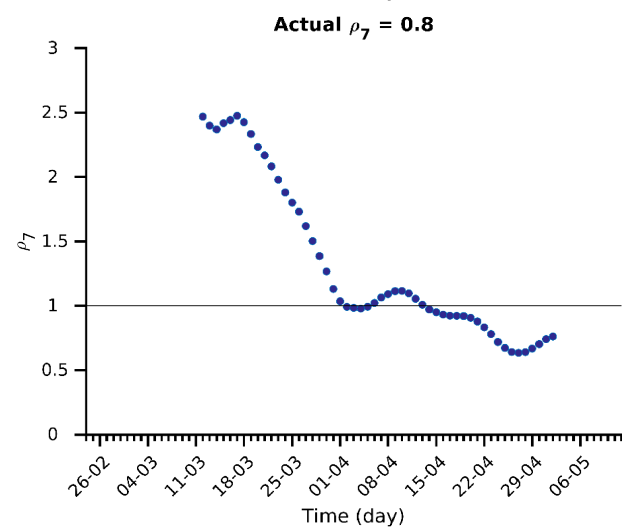
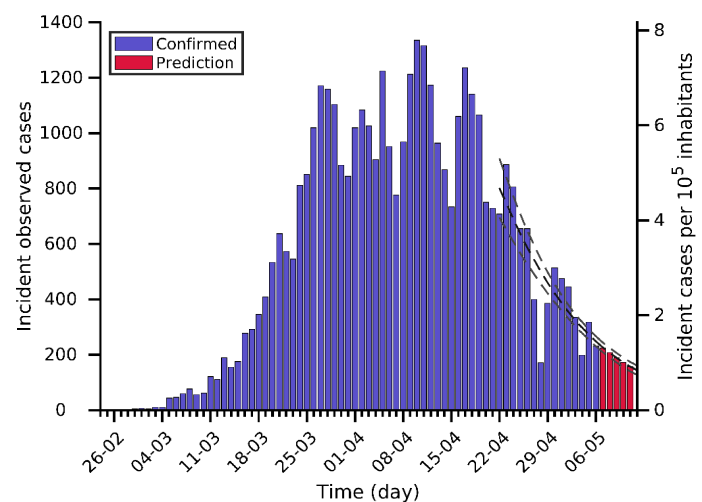
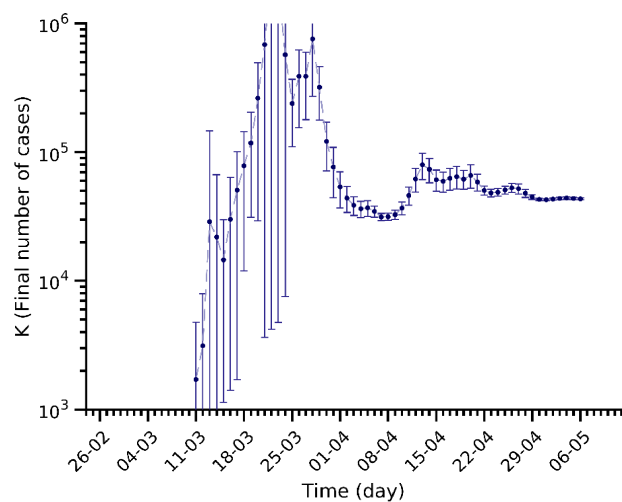
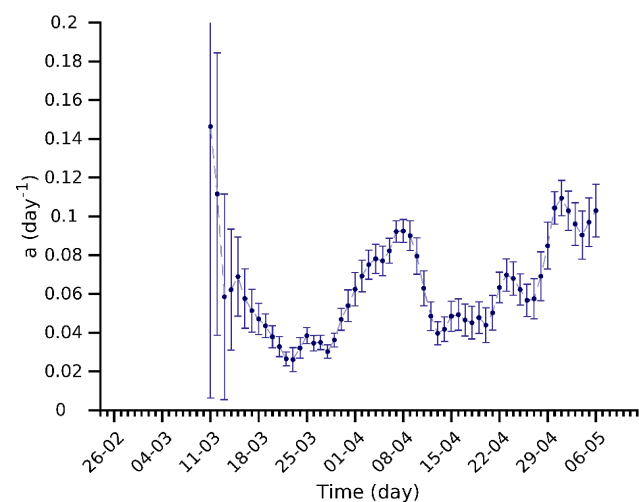
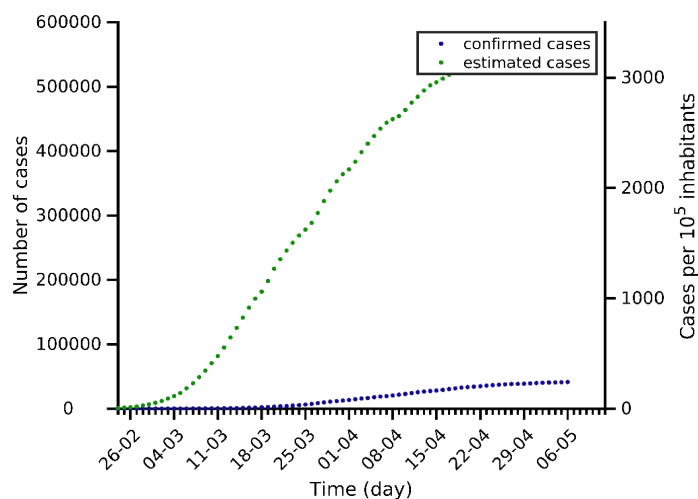
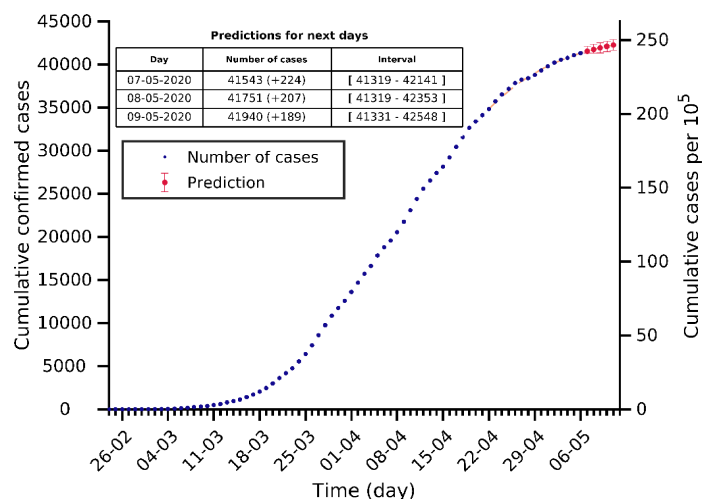




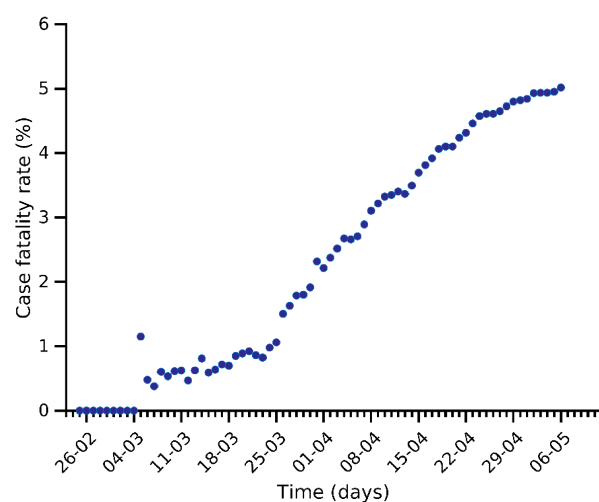
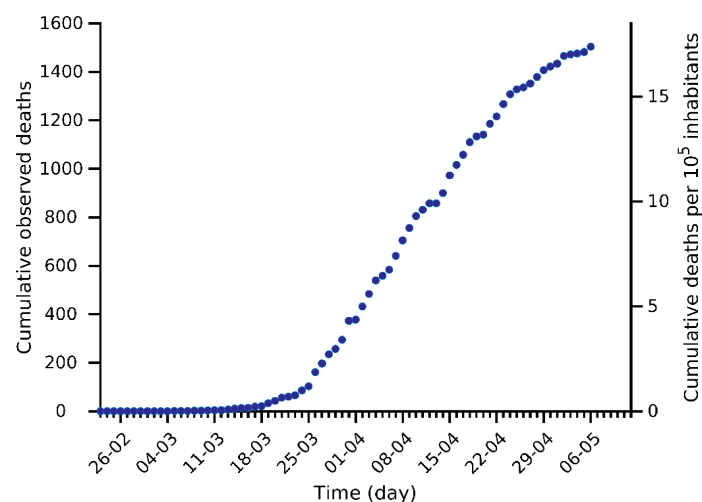
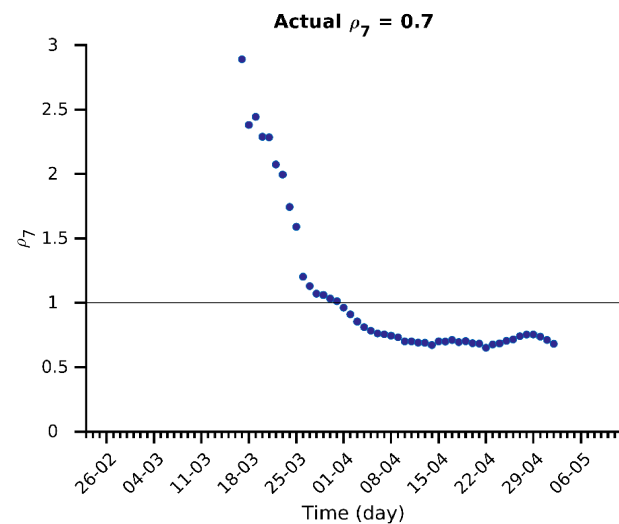
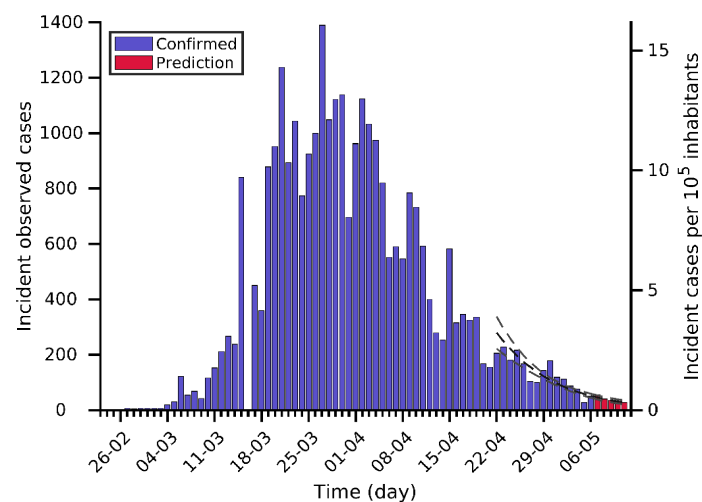
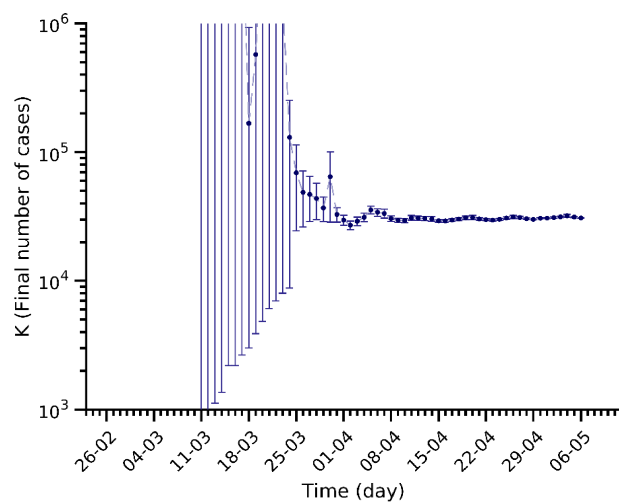
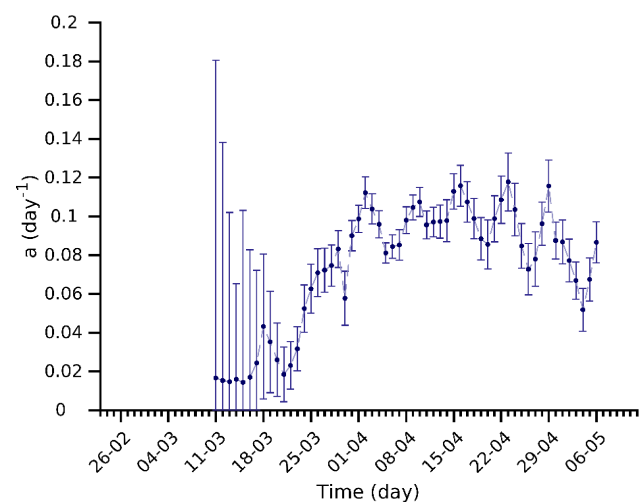
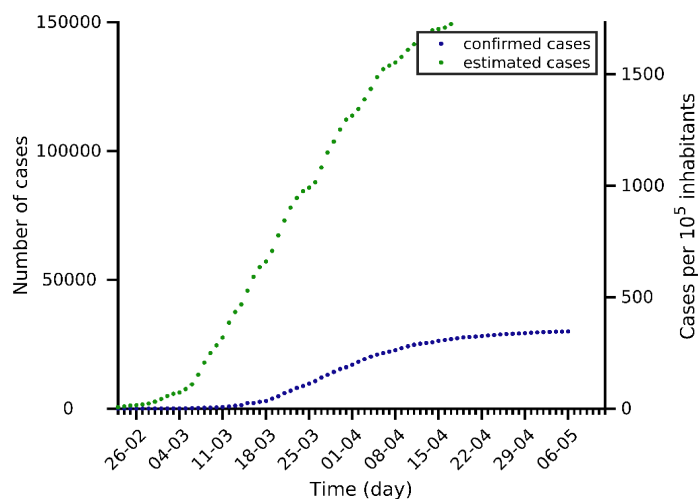
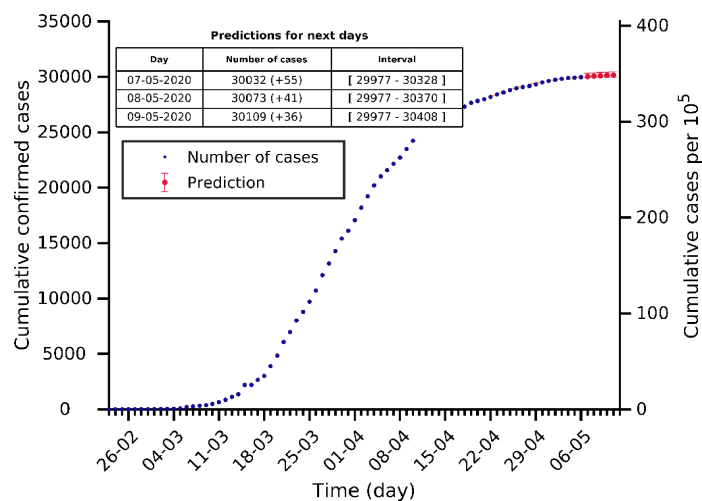
Belgium 06-05-2020. Population: 11.6M. Current cumulated incidence: 438/10⁵



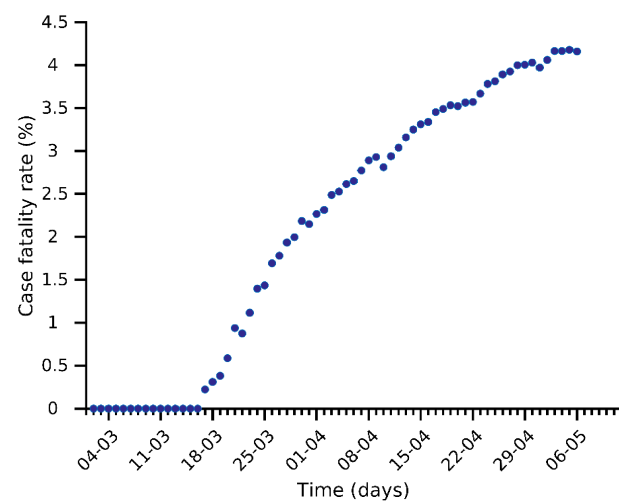
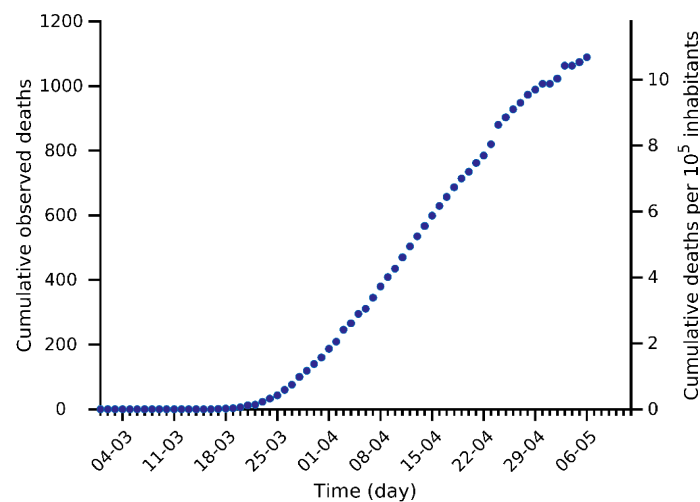
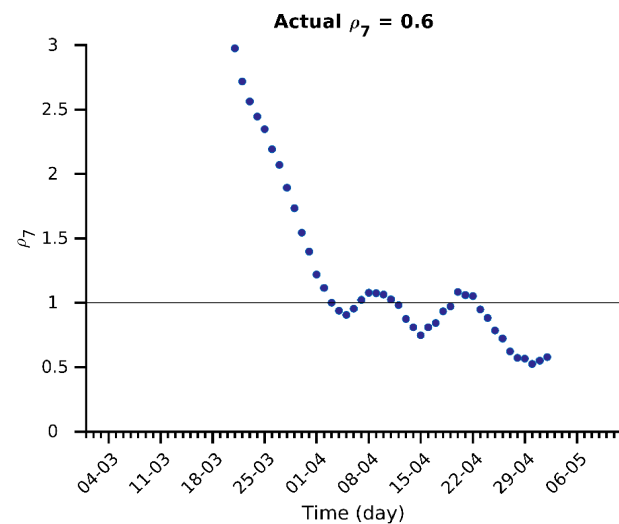
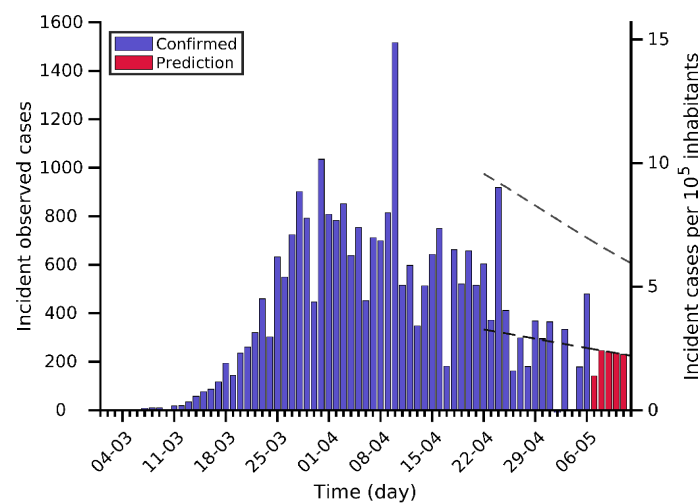
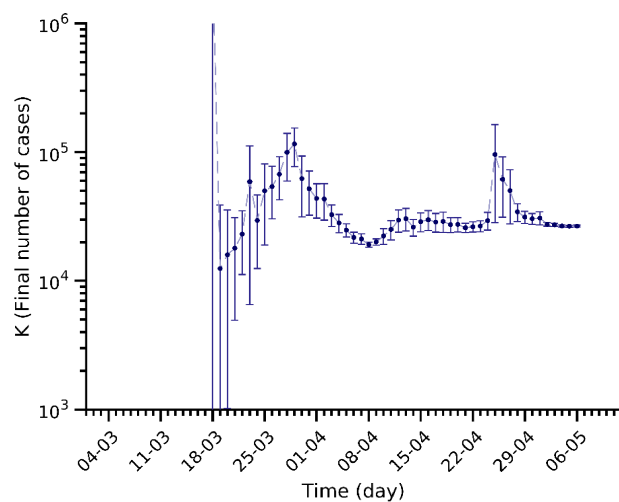
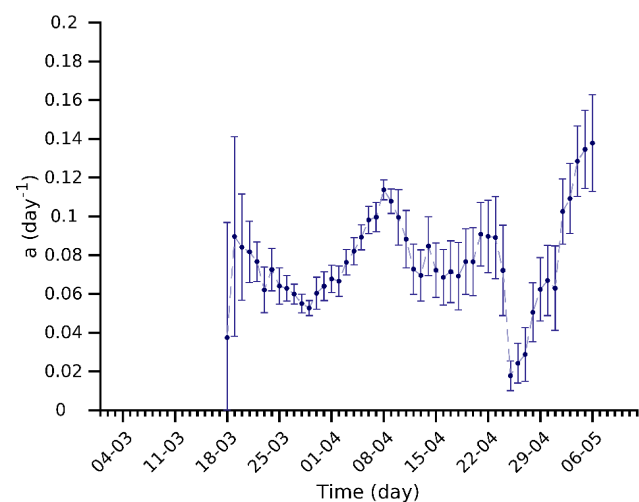
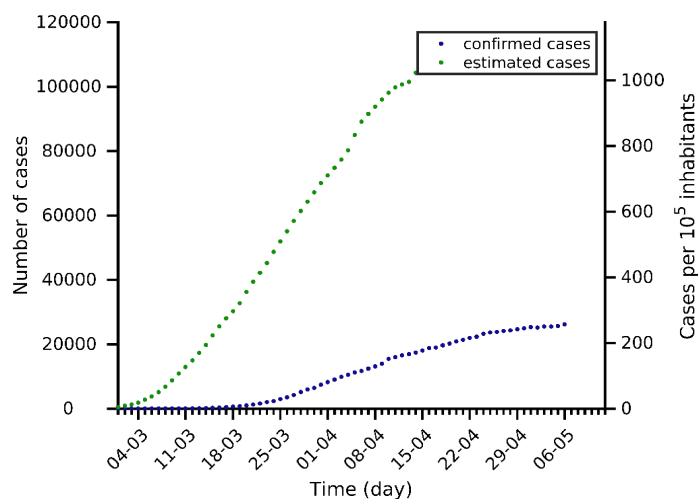
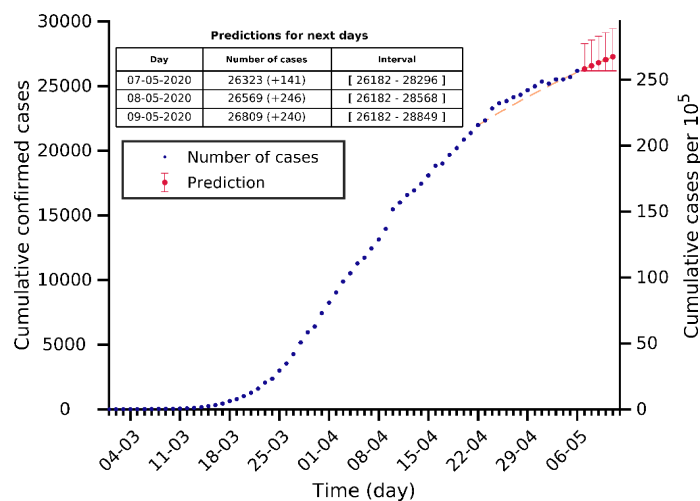
Netherlands 06-05-2020. Population: 17.1M. Current cumulated incidence: 241/10⁵



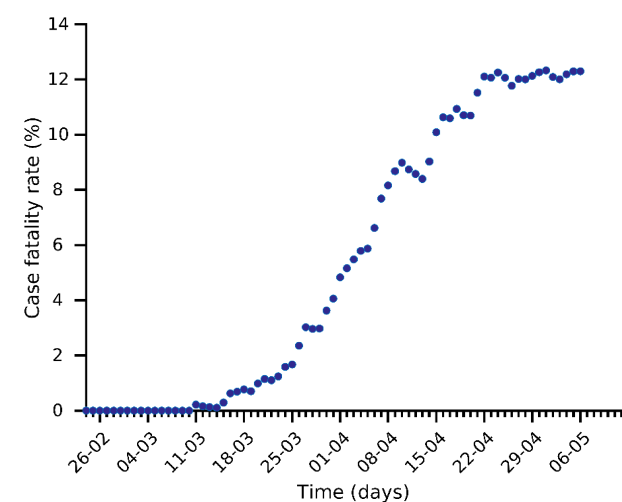
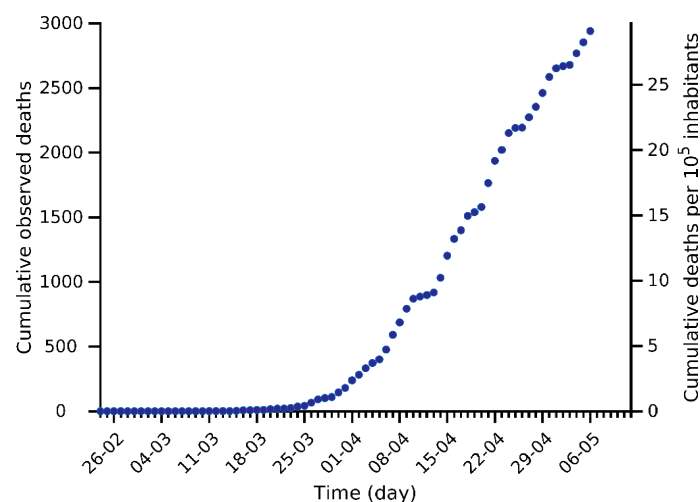
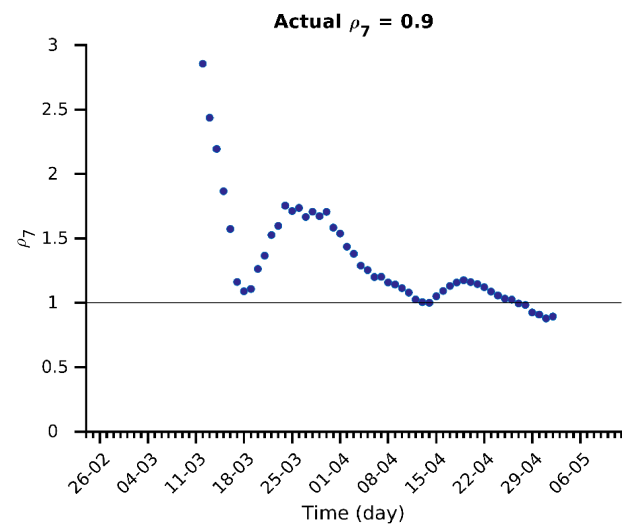
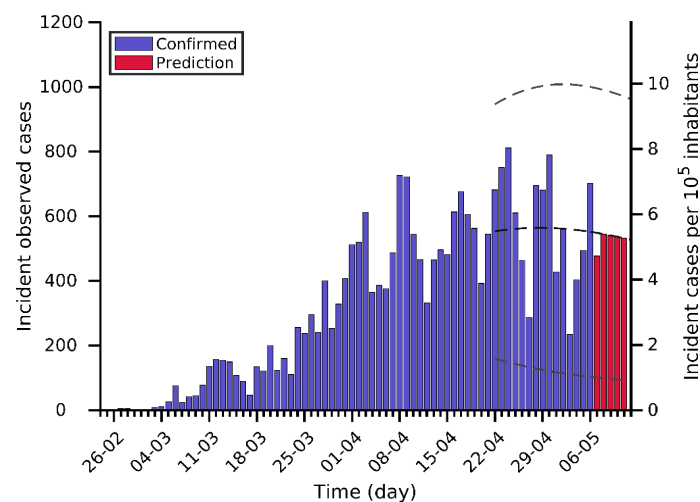
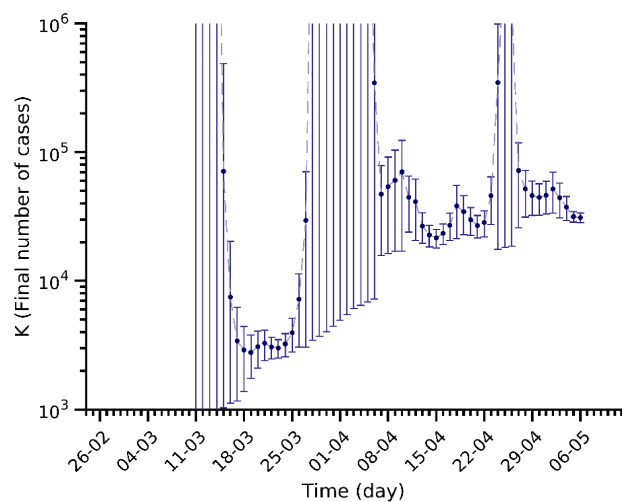
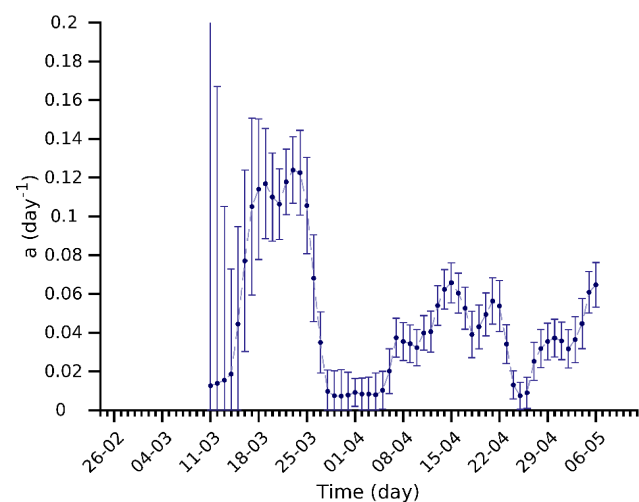
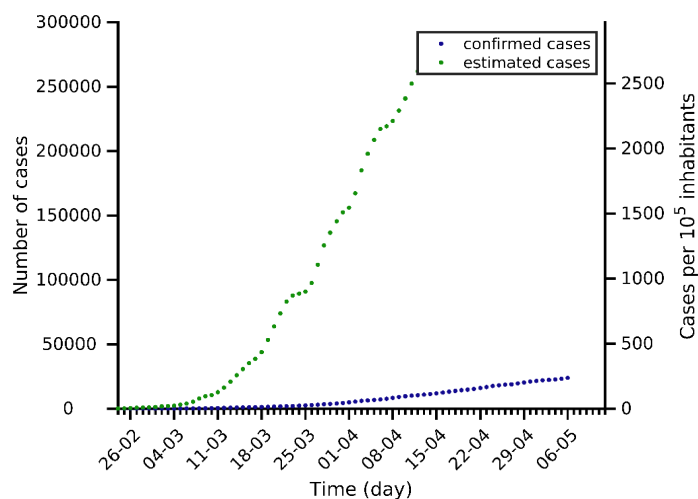
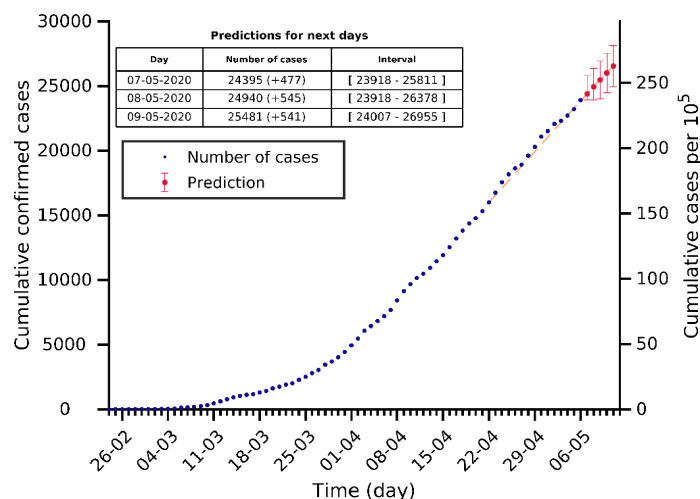
Switzerland 06-05-2020. Population: 8.7M. Current cumulated incidence: 346/10⁵



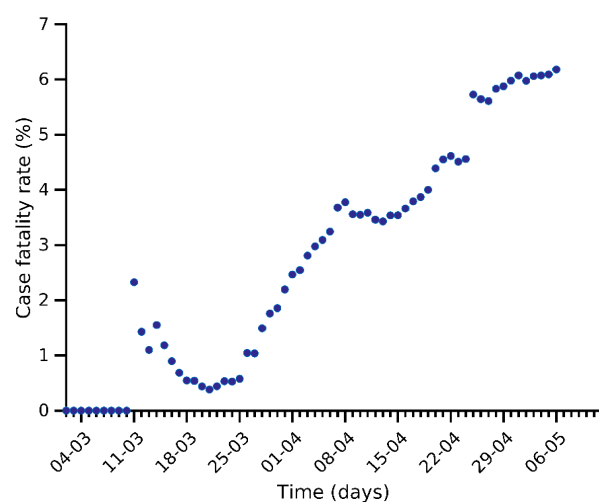
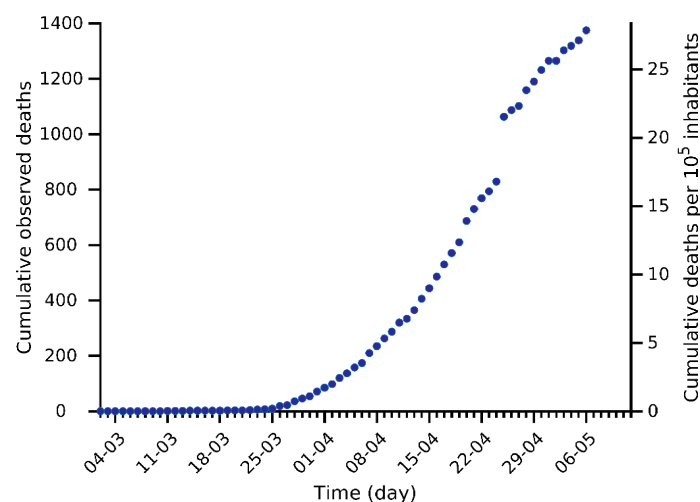
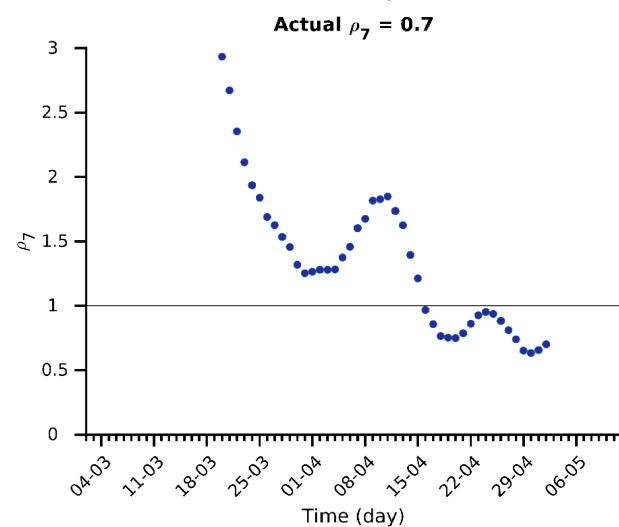
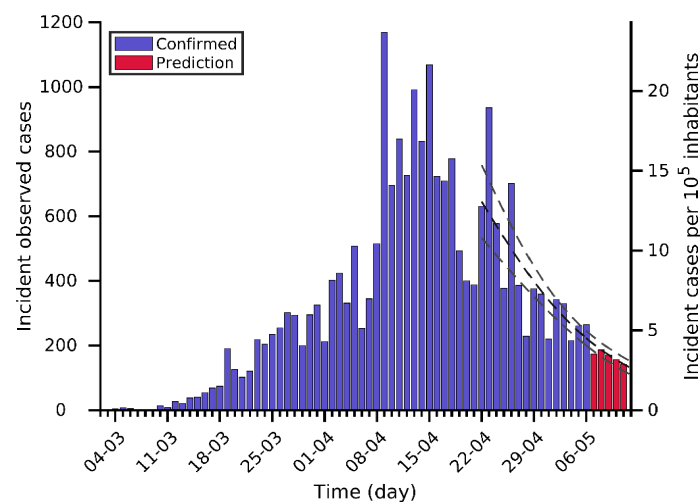
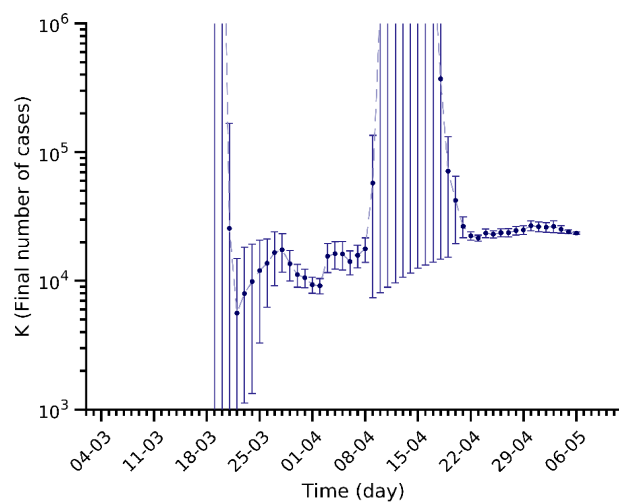
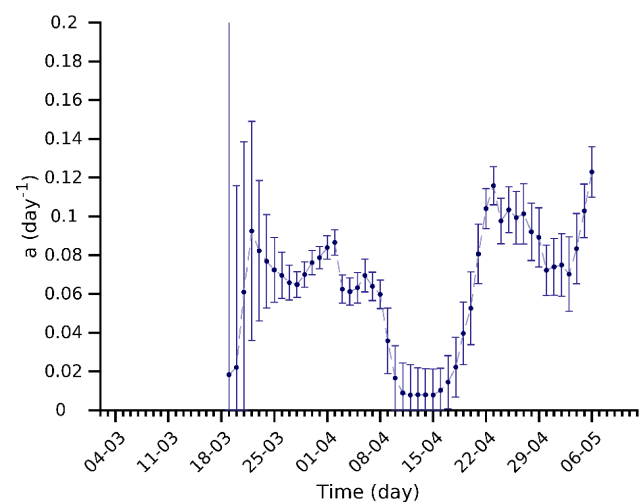
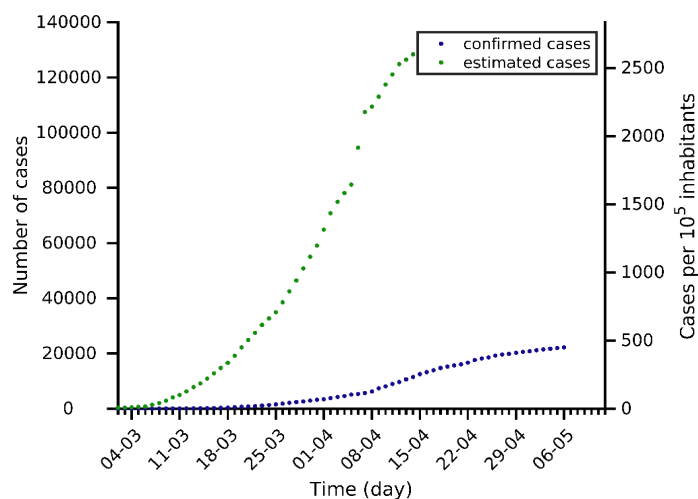
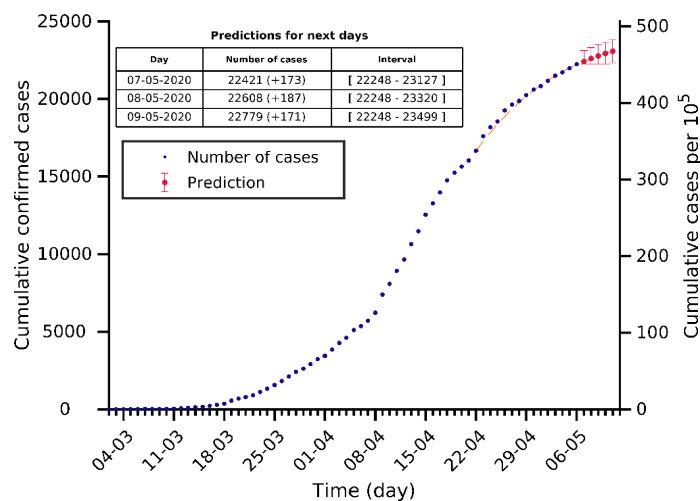
Portugal 06-05-2020. Population: 10.2M. Current cumulated incidence: 257/10⁵



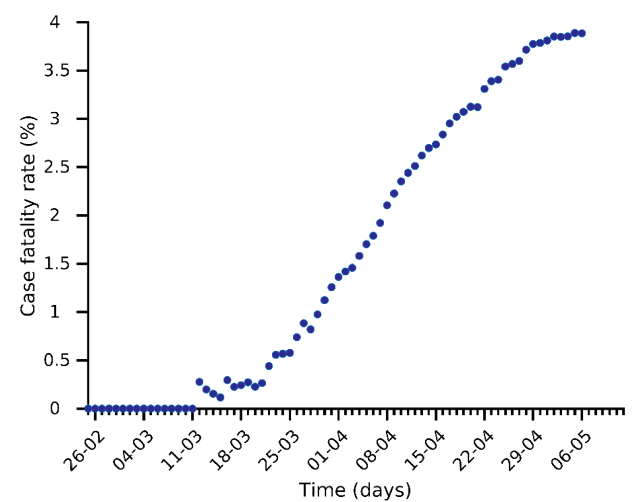
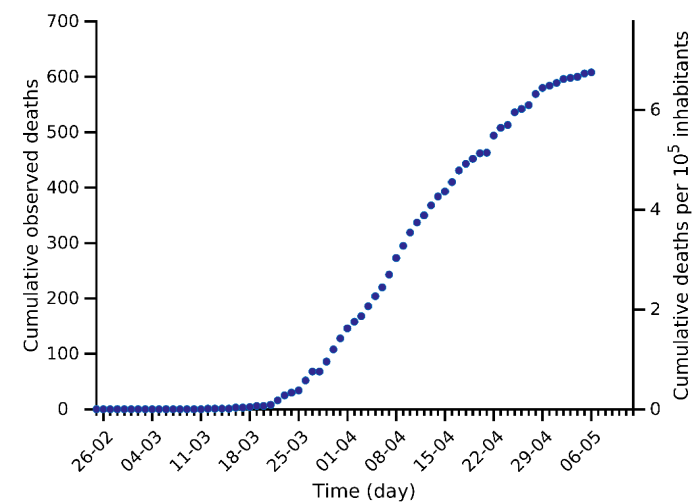
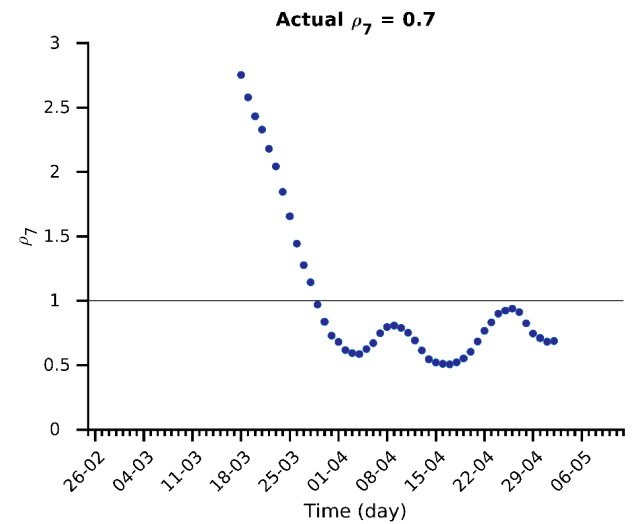
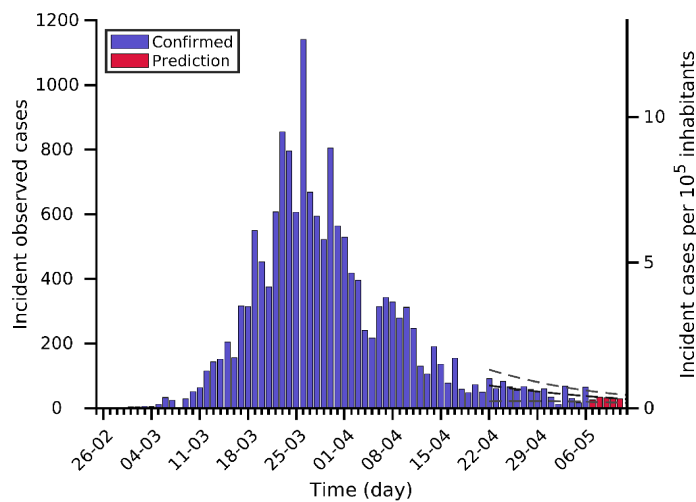
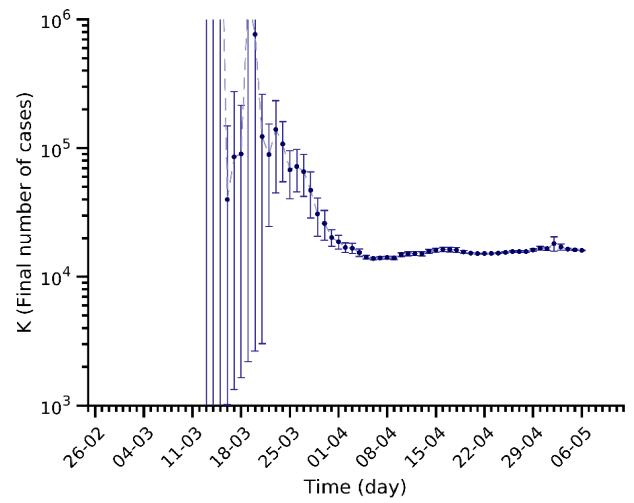
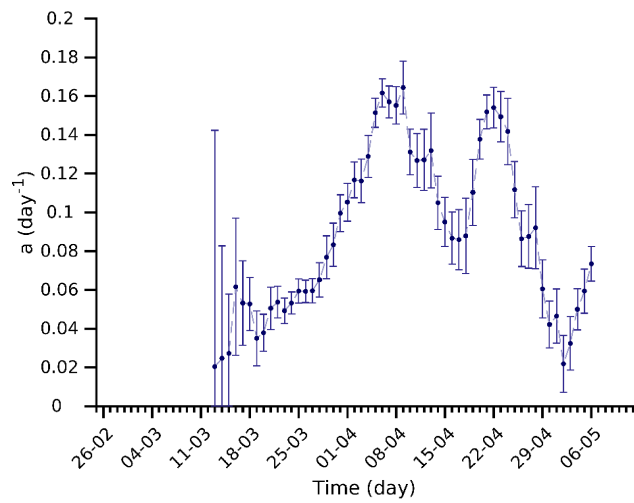
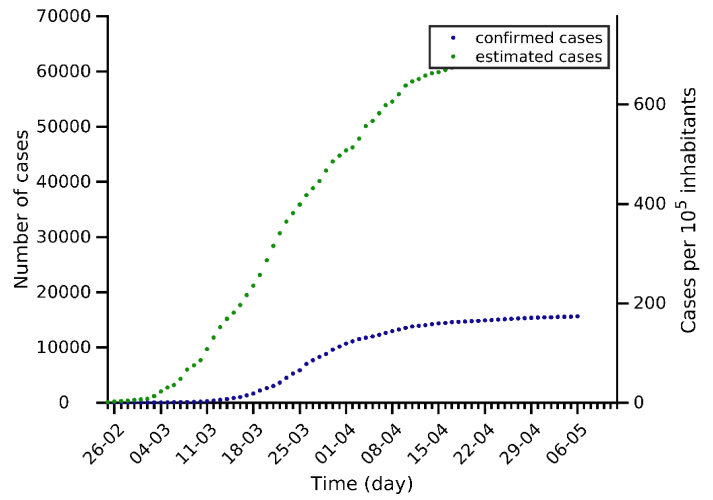
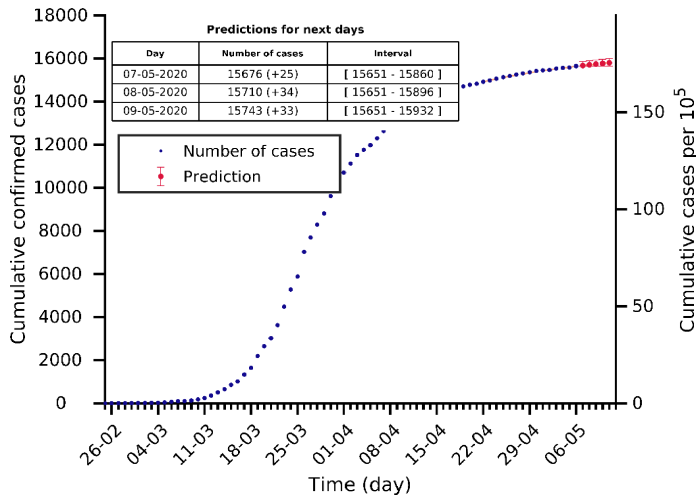
Sweden 06-05-2020. Population: 10.1M. Current cumulated incidence: 237/10⁵



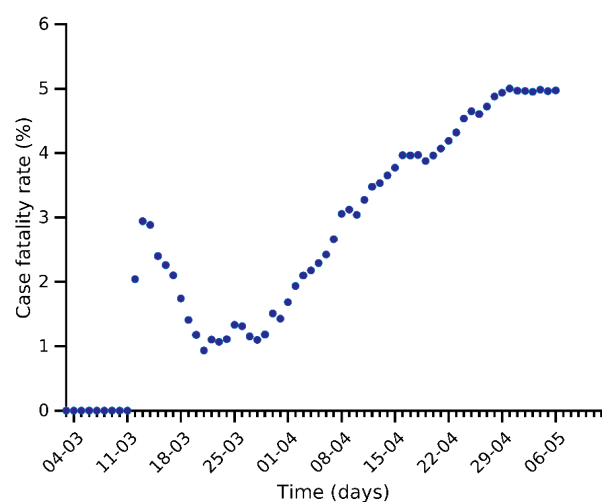
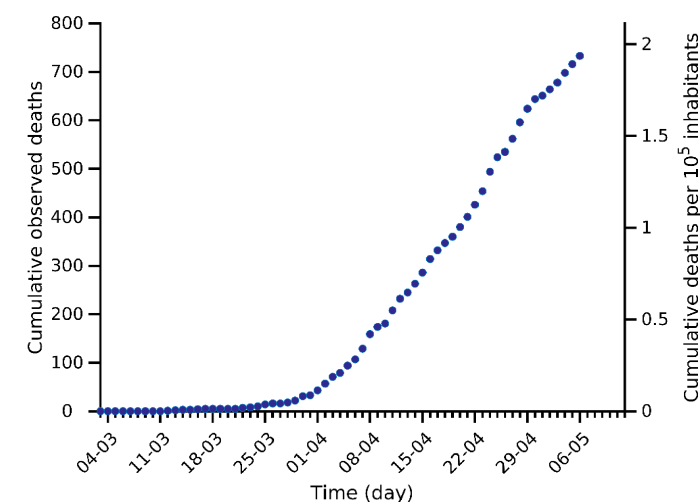
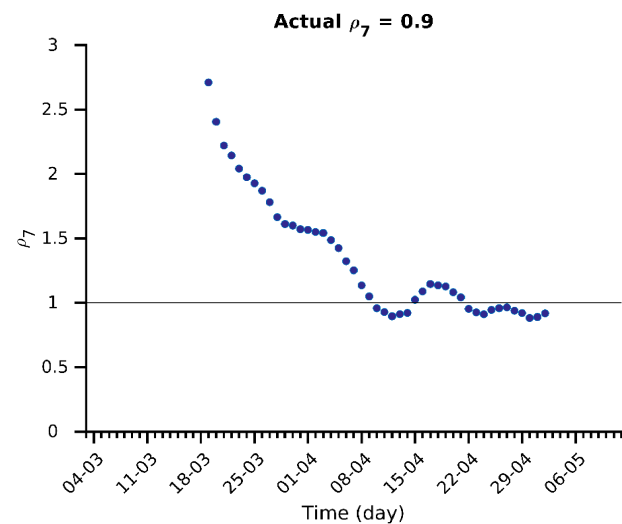
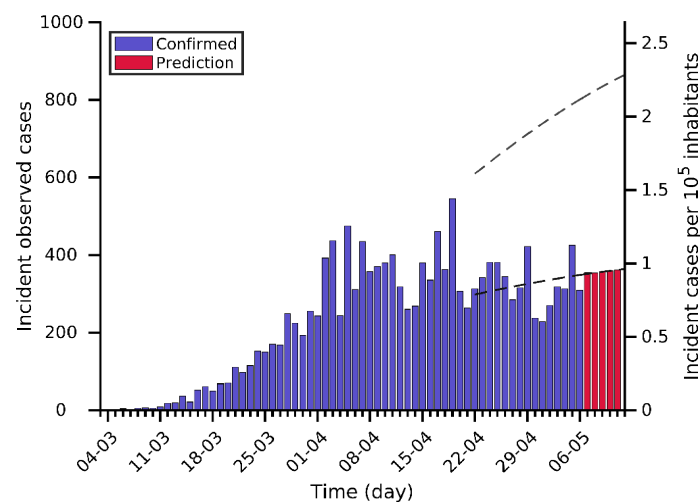
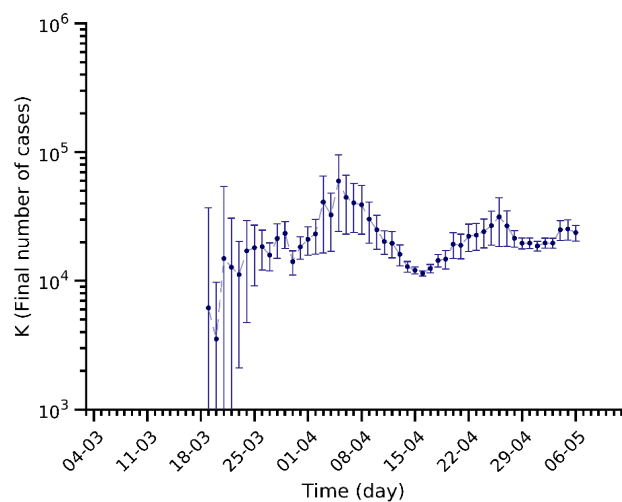
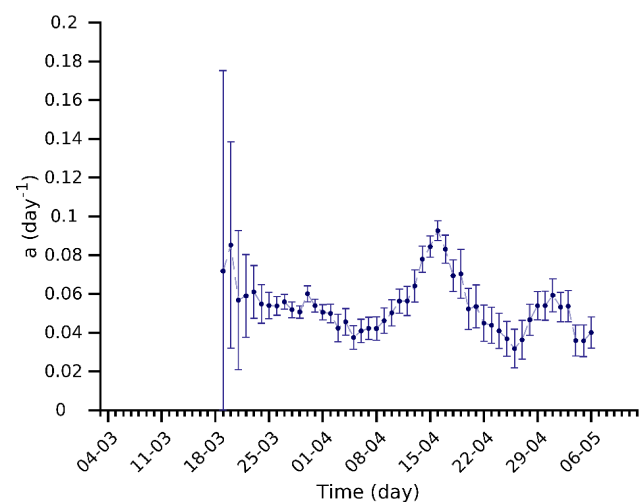
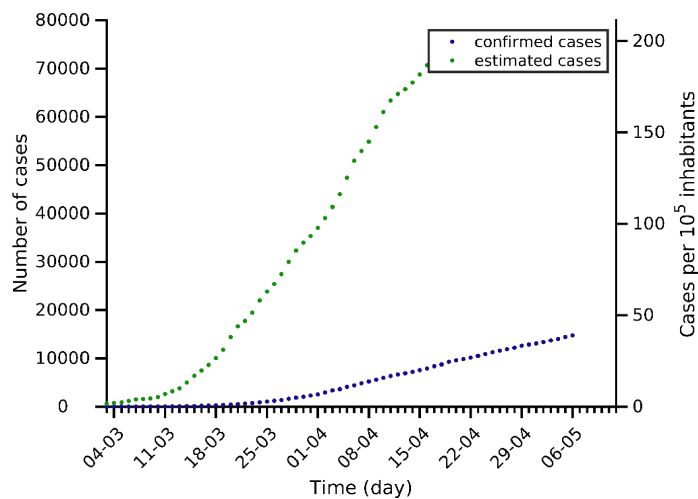
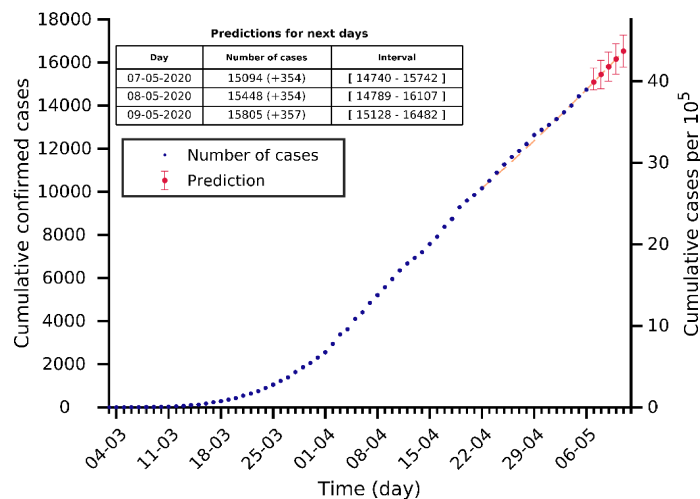
Ireland 06-05-2020. Population: 4.9M. Current cumulated incidence: 451/10⁵



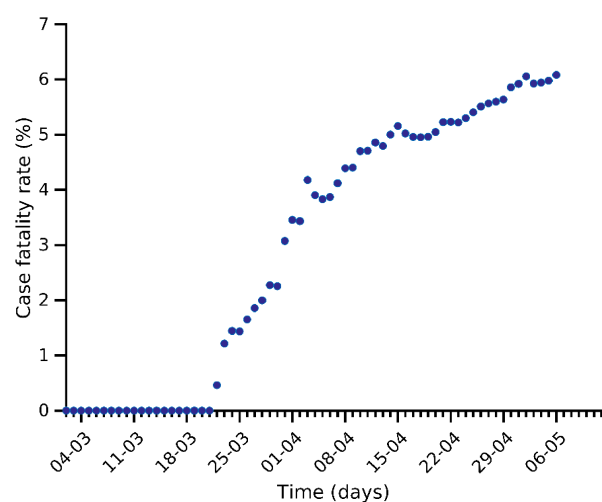
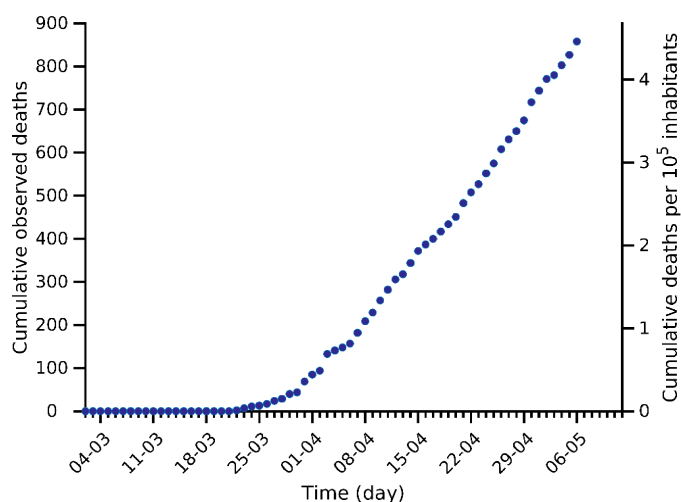
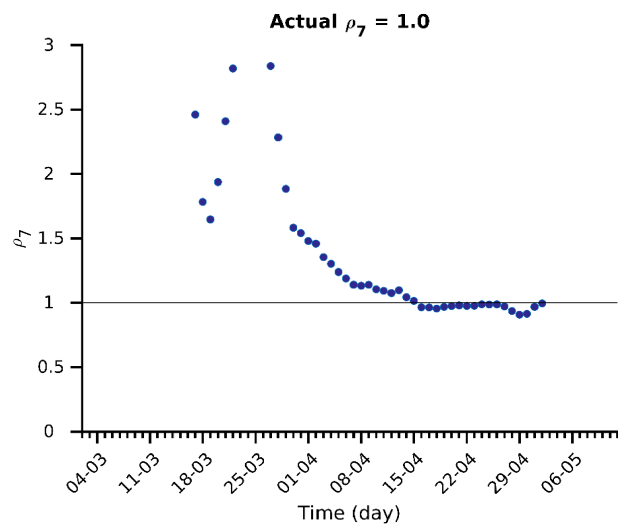
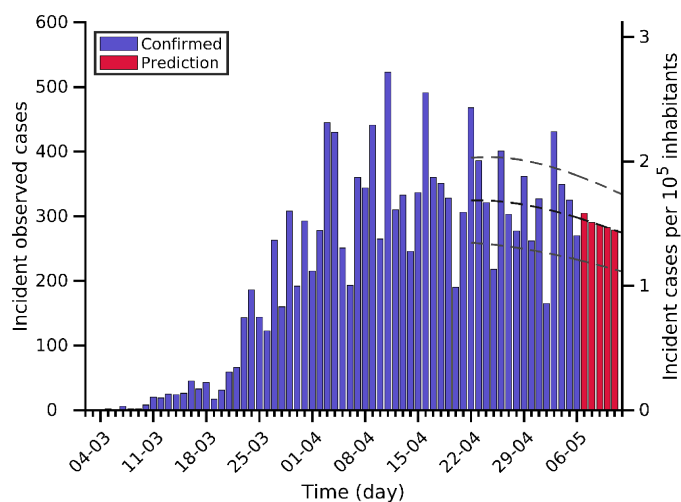
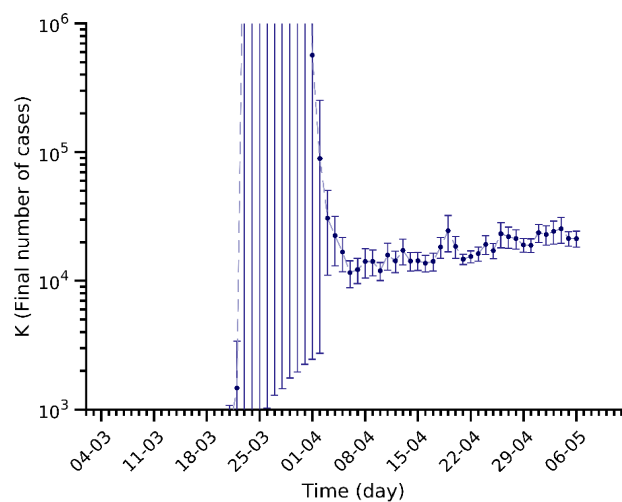
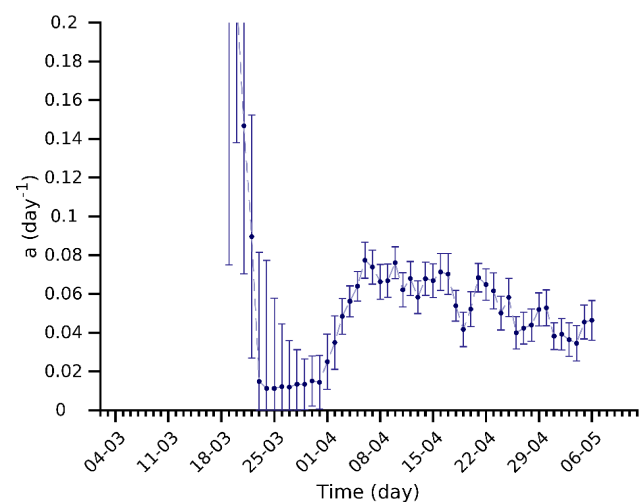
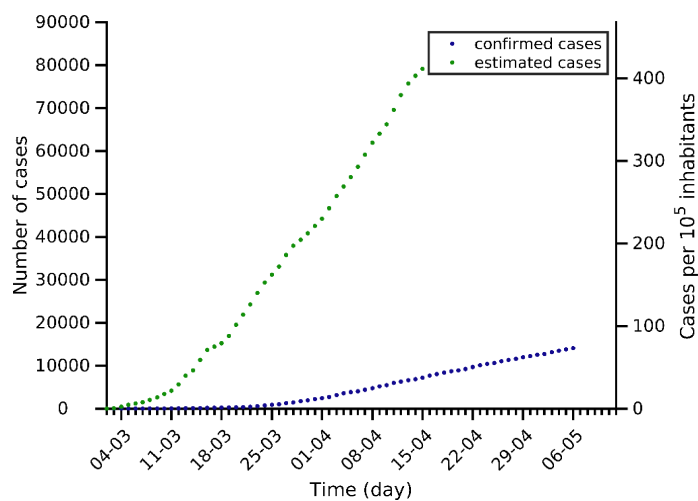
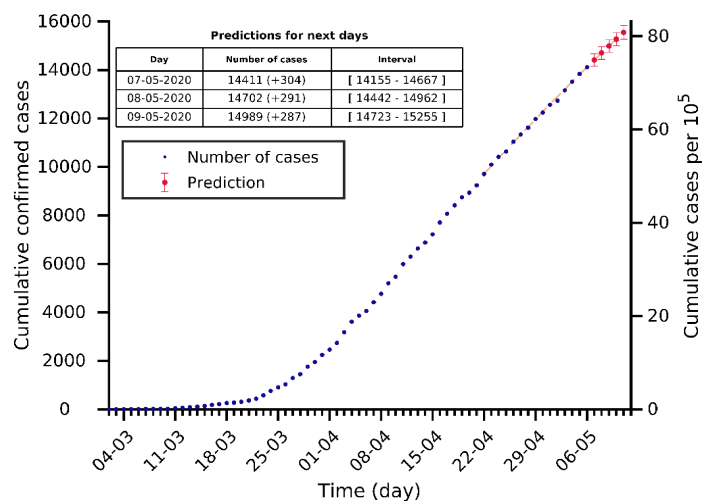
Austria 06-05-2020. Population: 9.0M. Current cumulated incidence: 174/10⁵



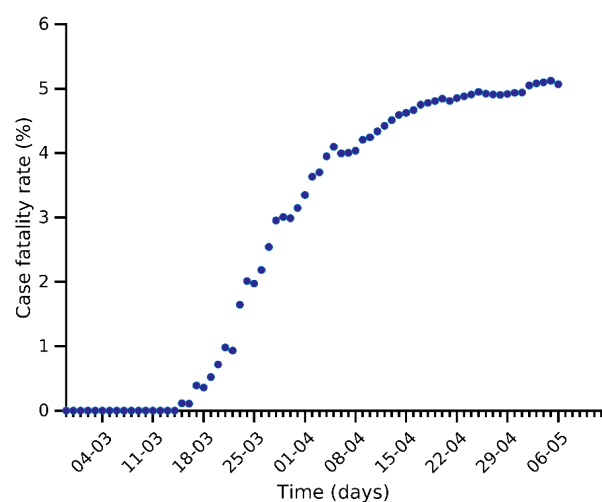
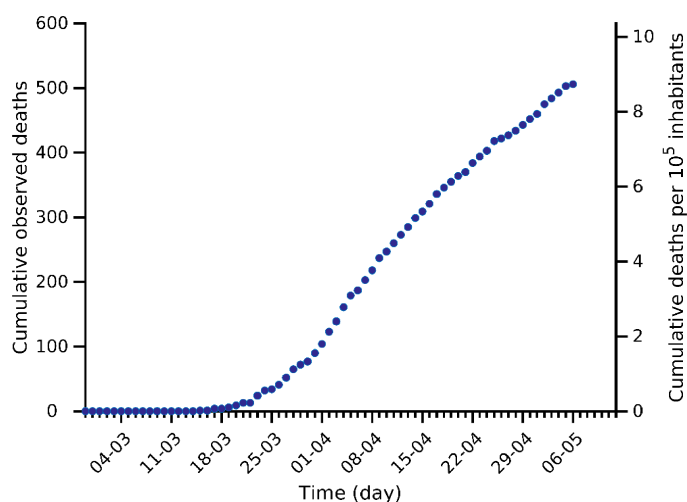
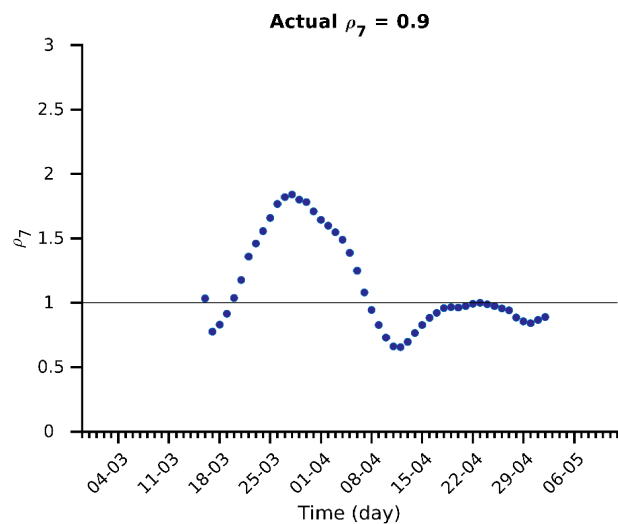
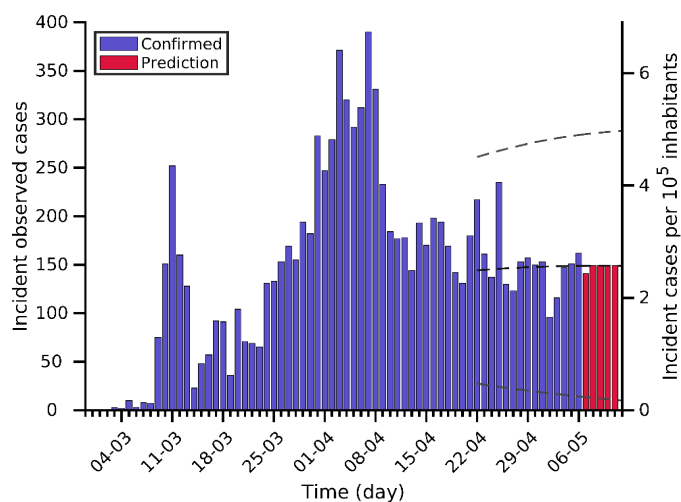
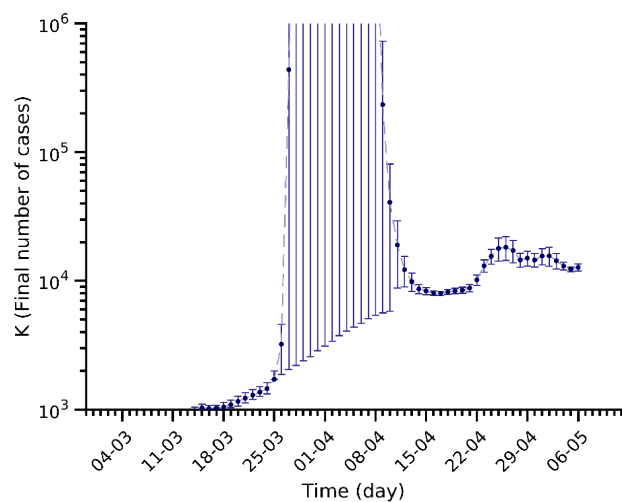
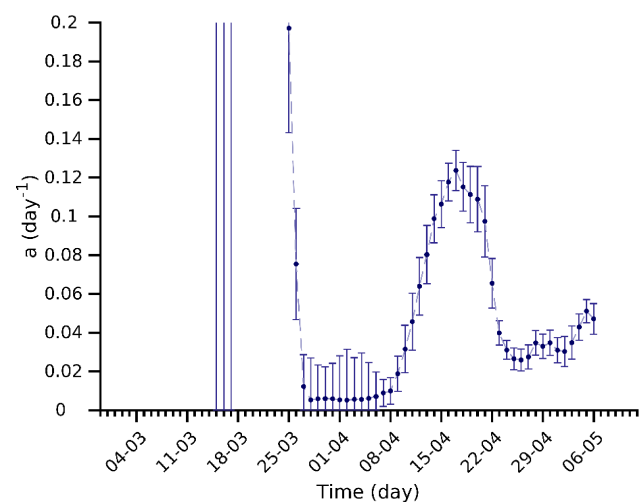
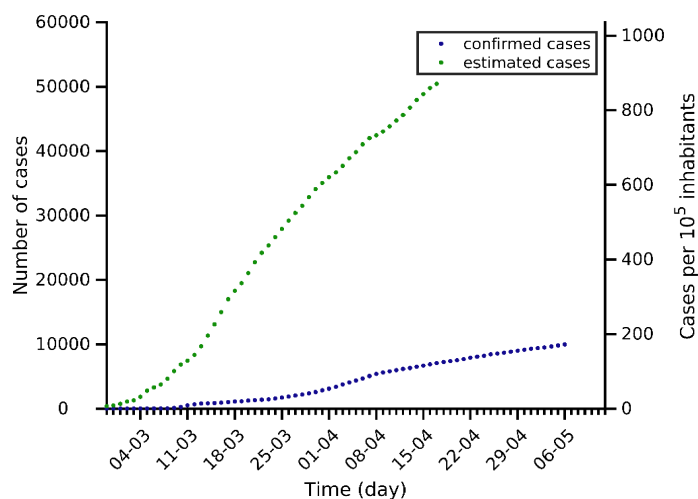
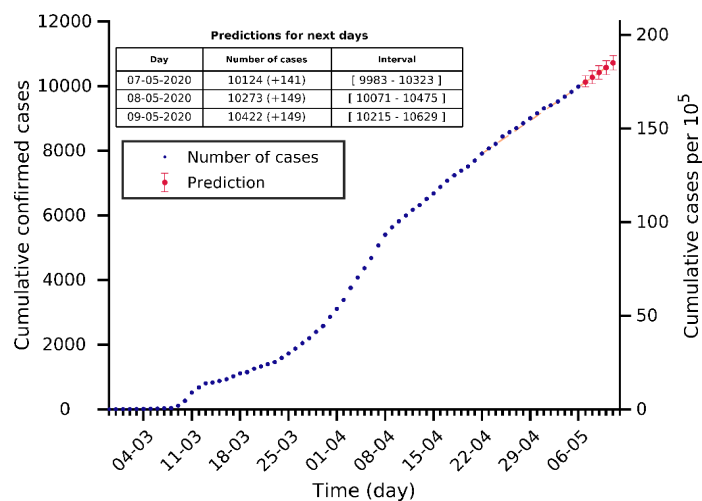
Poland 06-05-2020. Population: 37.8M. Current cumulated incidence: 39/10⁵

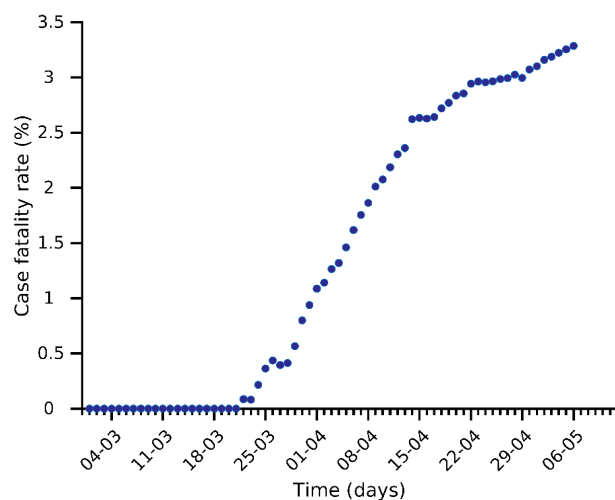
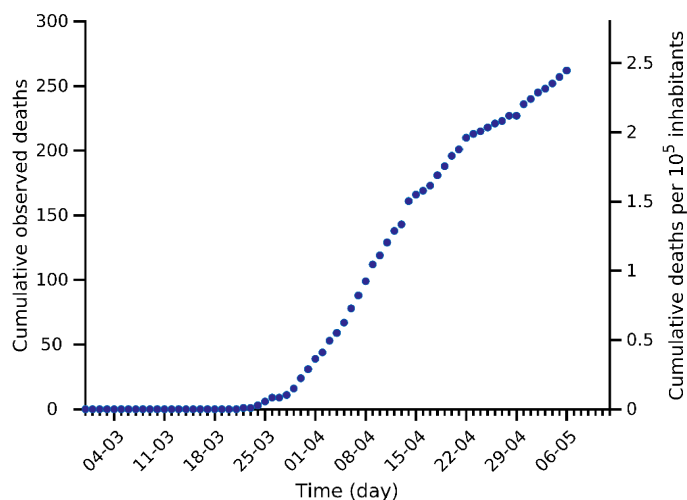
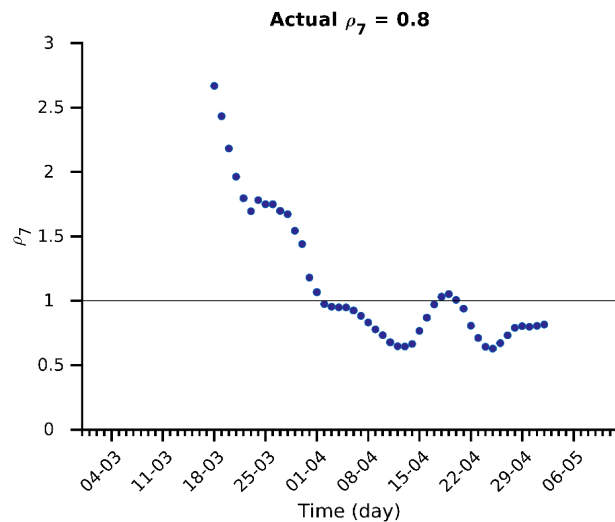
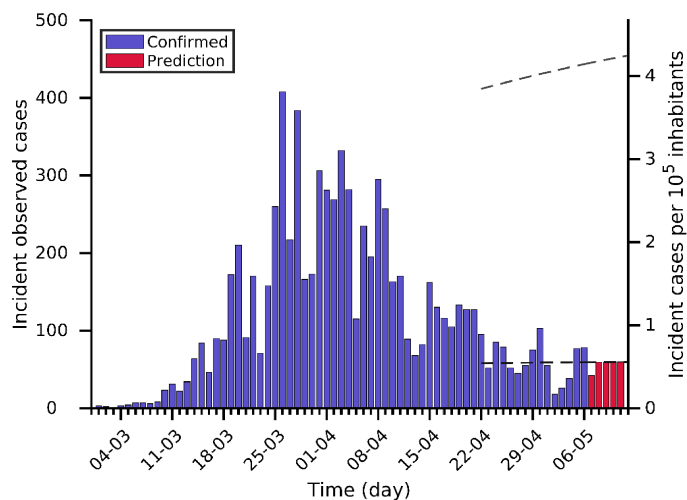
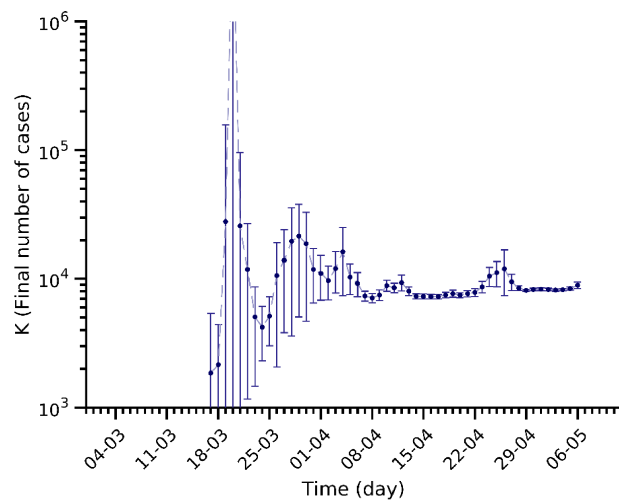
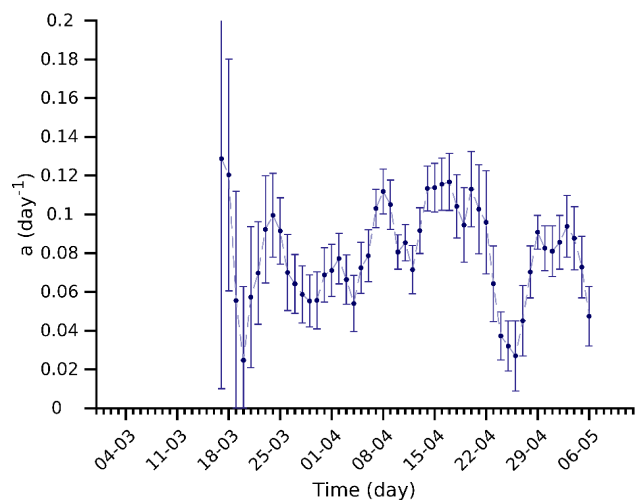
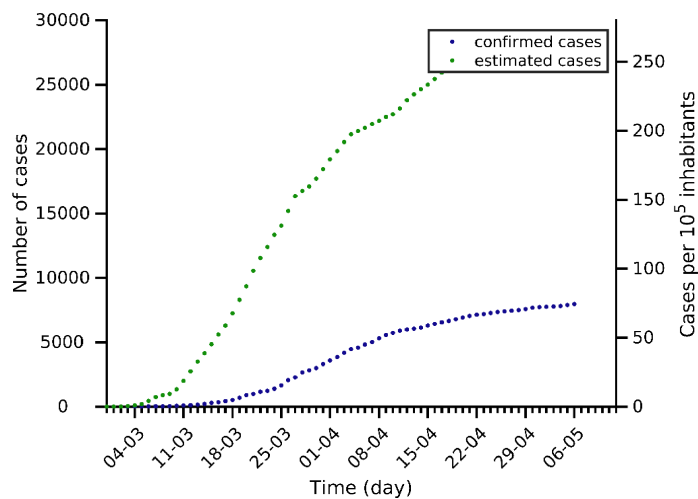
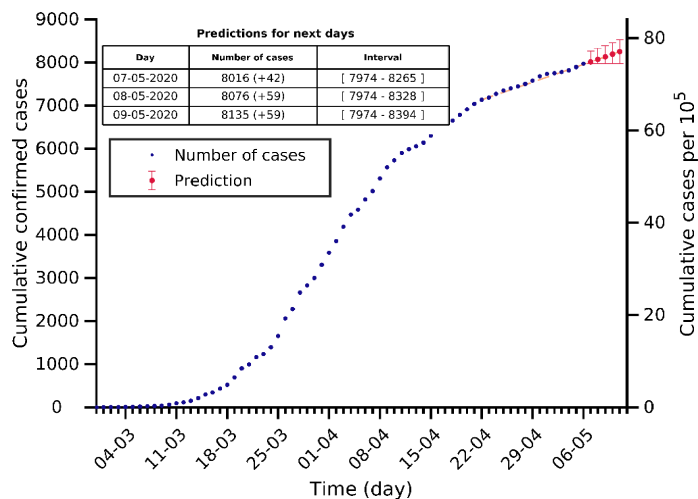


Romania 06-05-2020. Population: 19.2M. Current cumulated incidence: 73/10⁵

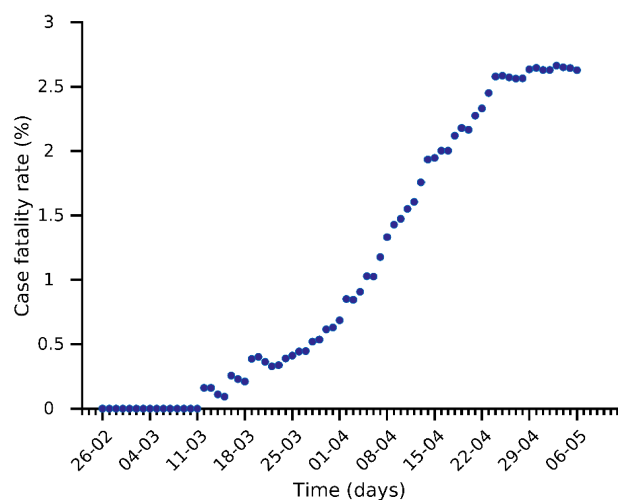
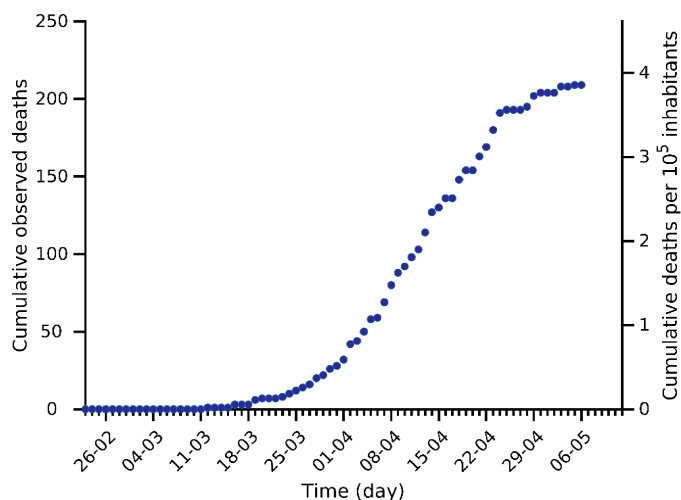
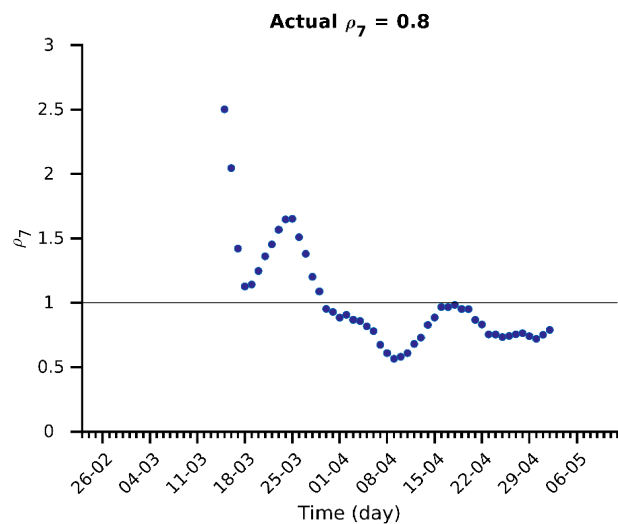
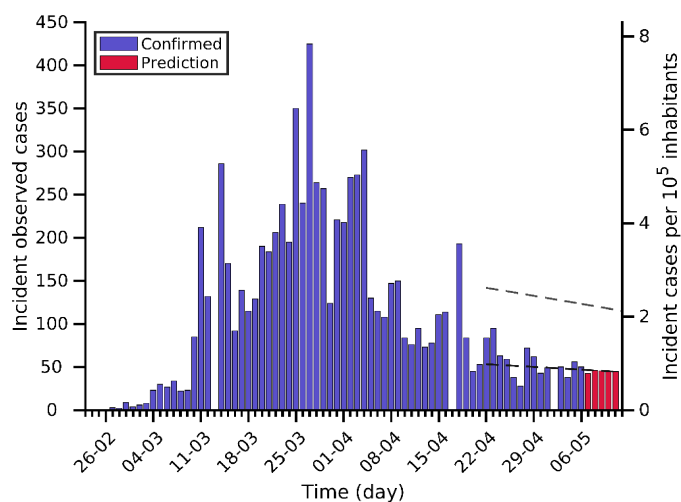
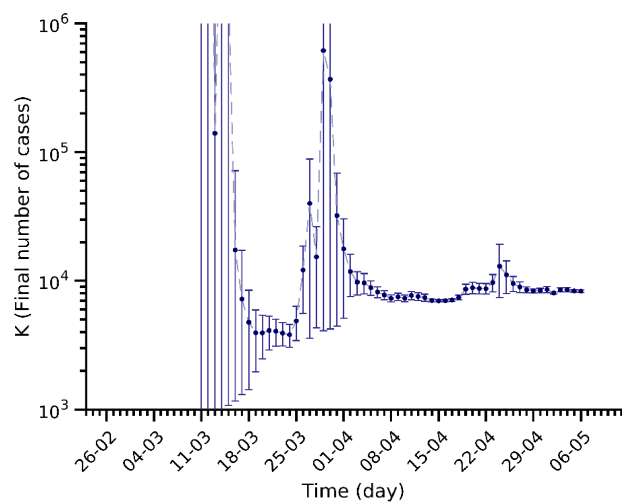
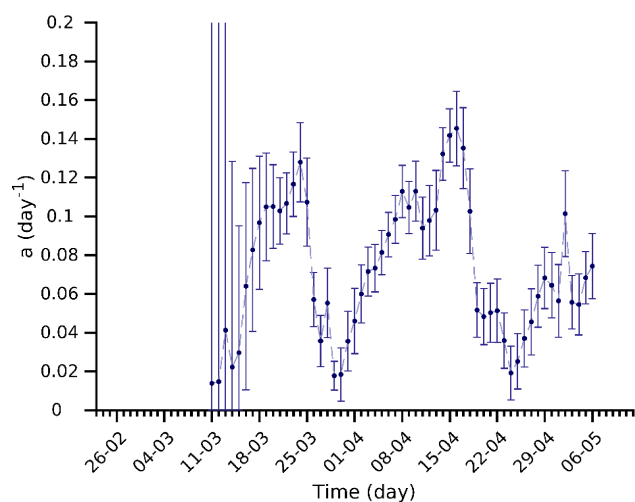
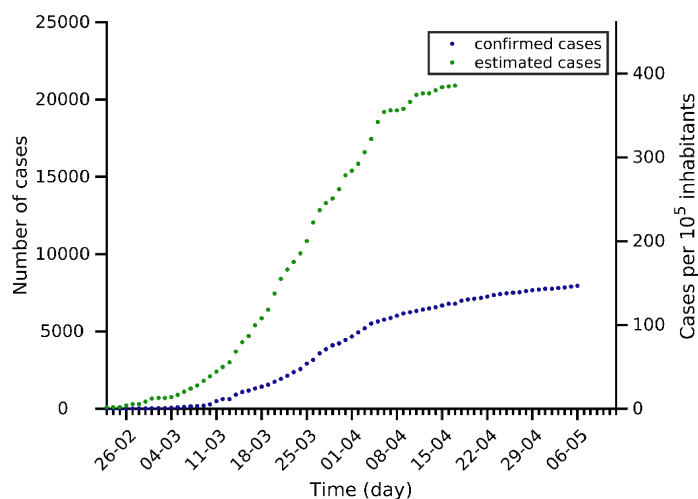
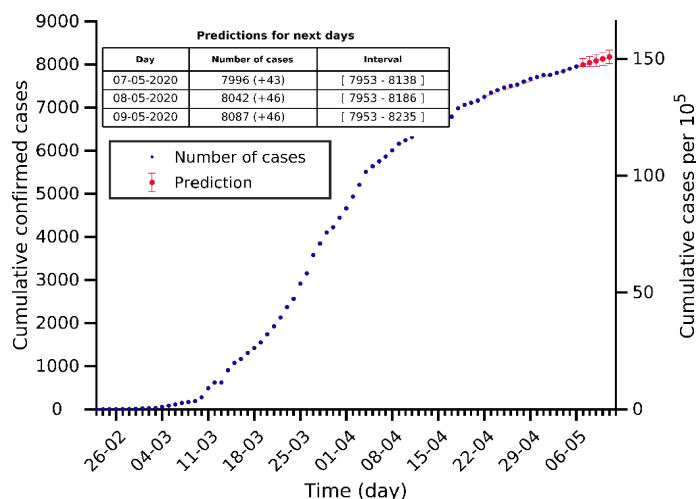


Denmark 06-05-2020. Population: 5.8M. Current cumulated incidence: 172/10⁵

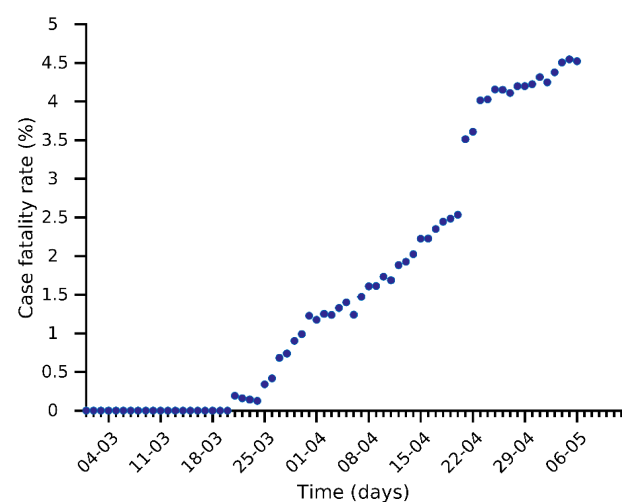
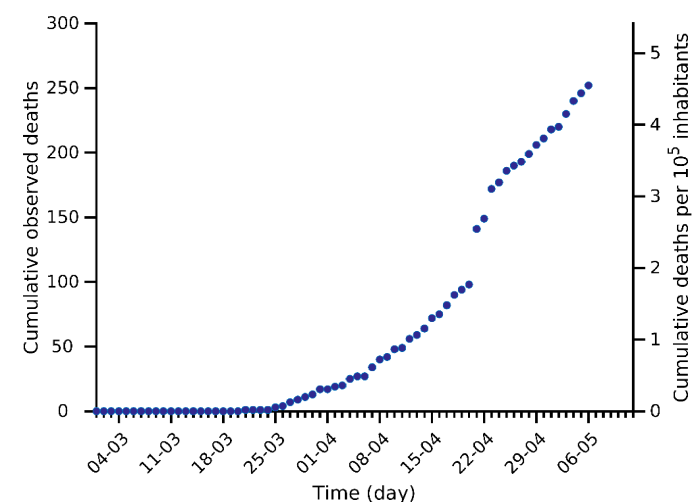
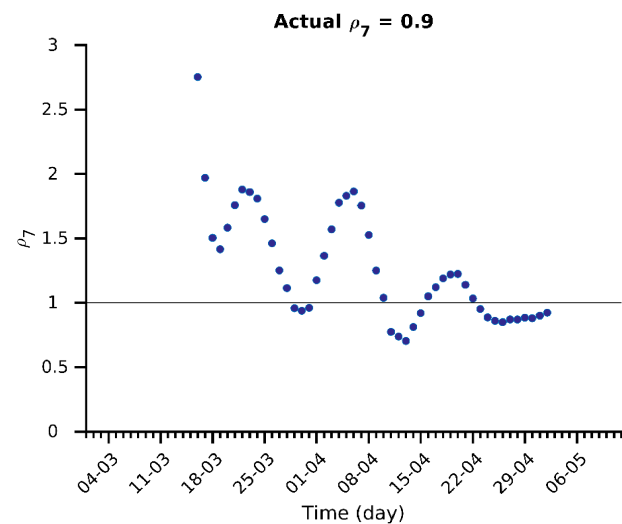
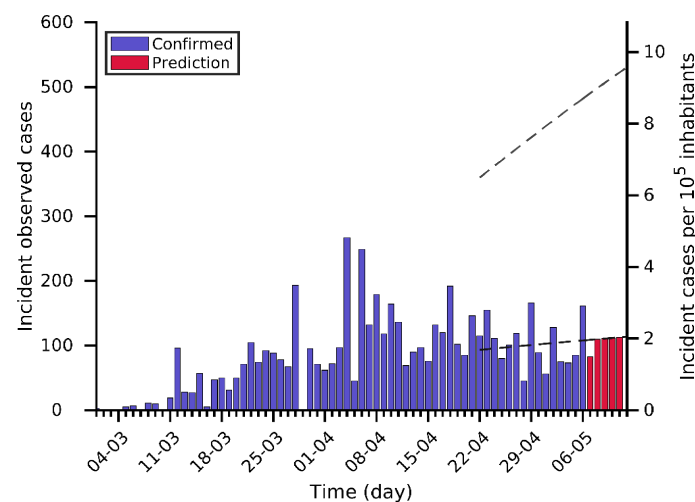
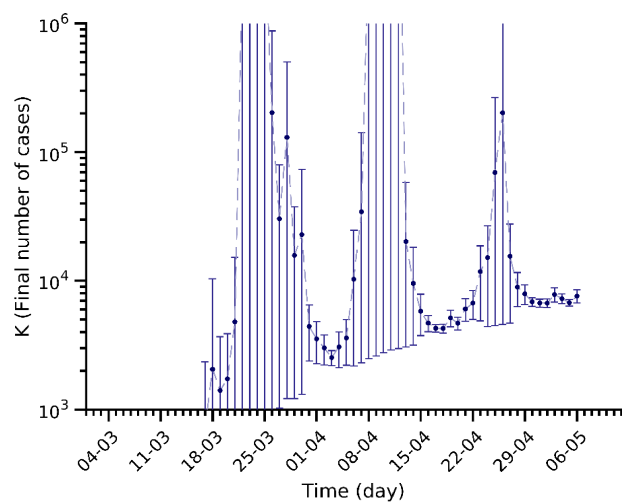
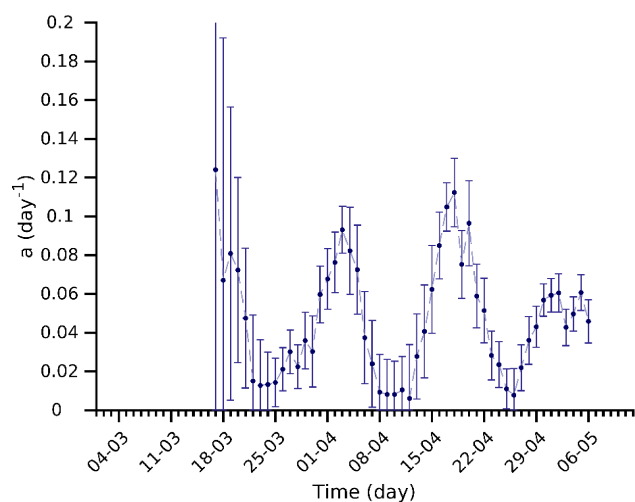
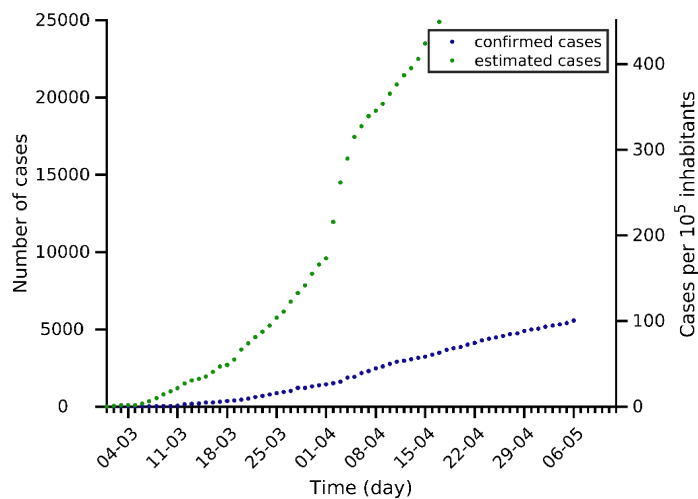
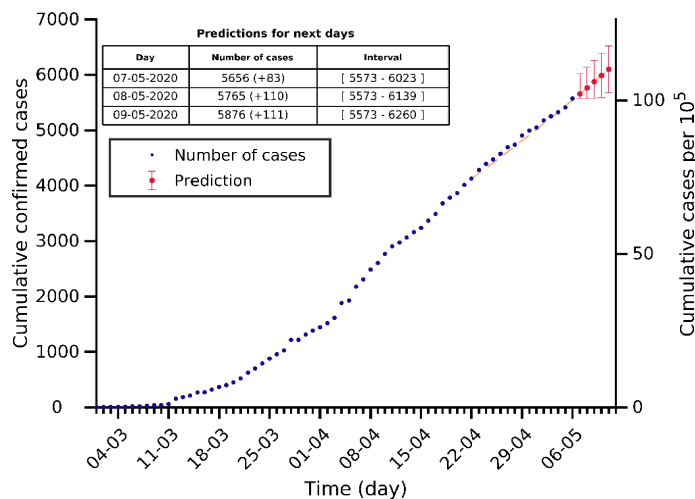




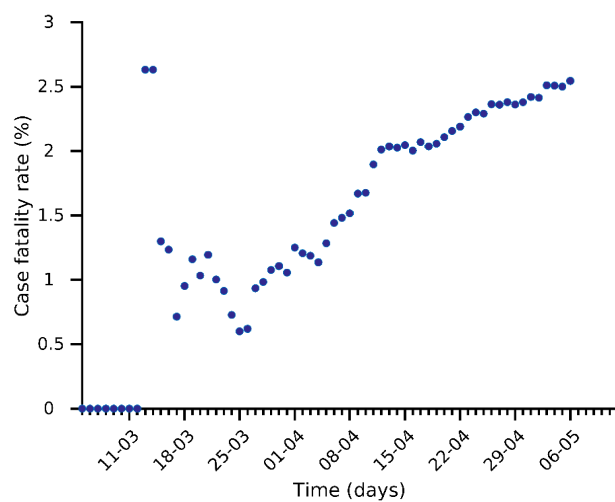
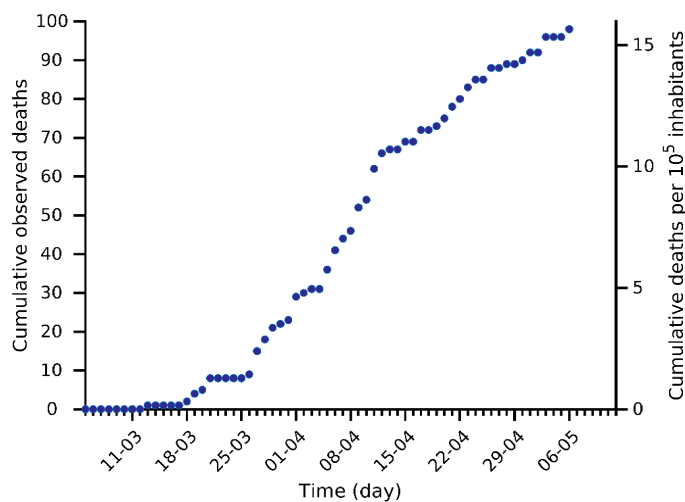
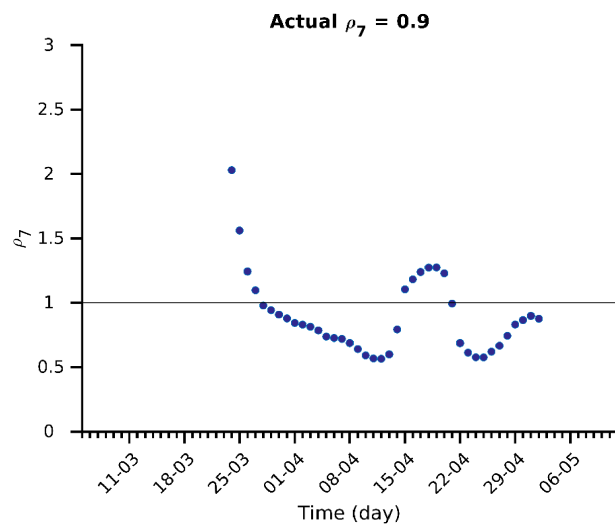
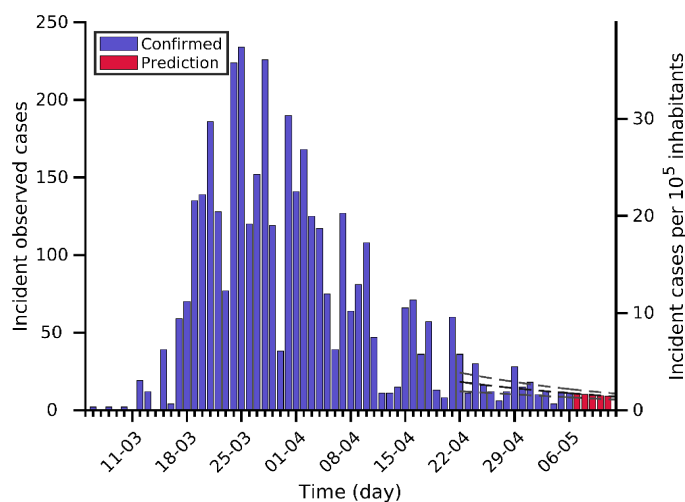
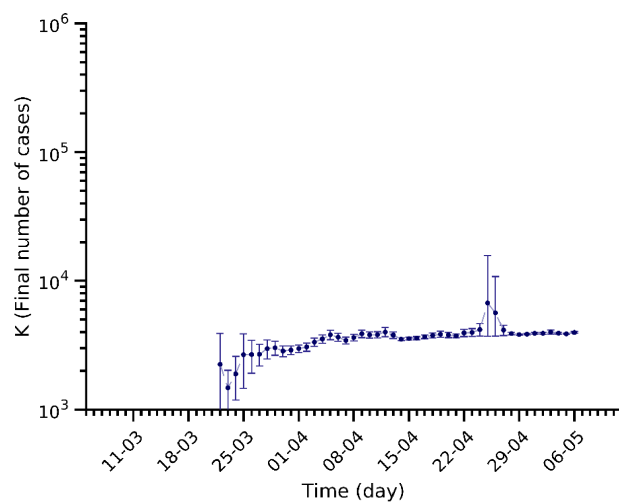
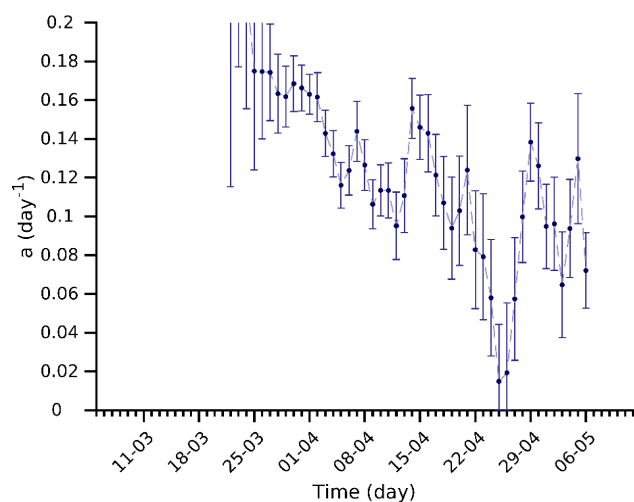
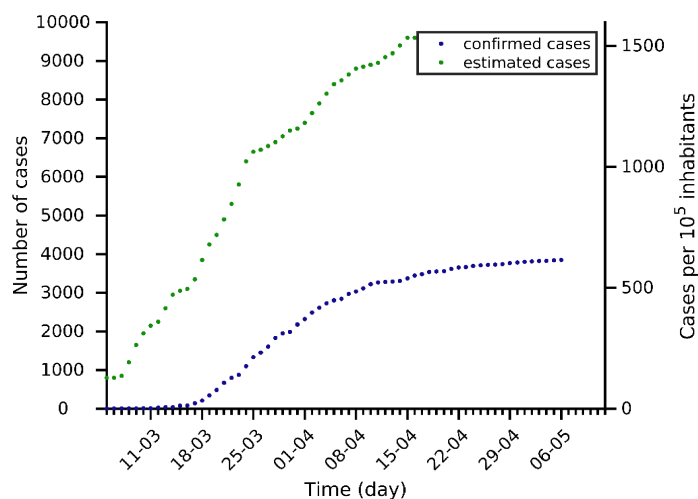
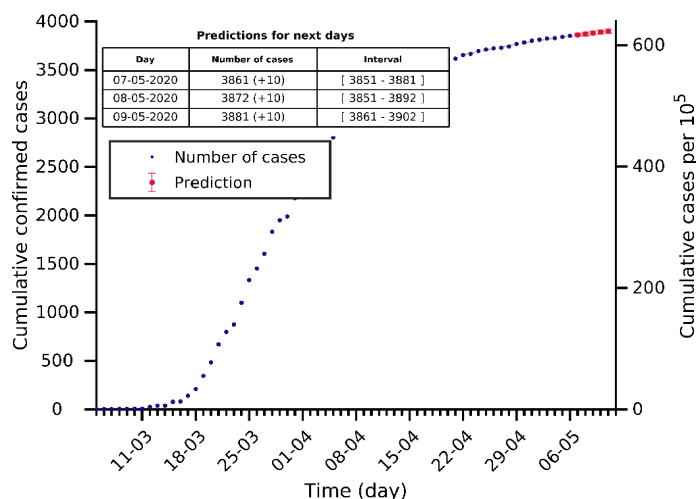
Norway 06-05-2020. Population: 5.4M. Current cumulated incidence: 147/10⁵



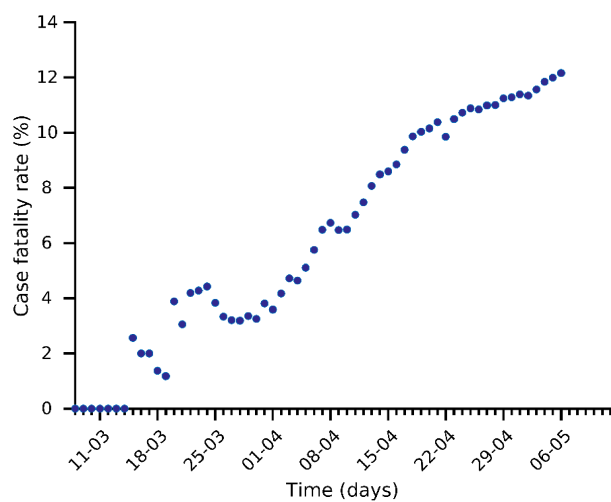
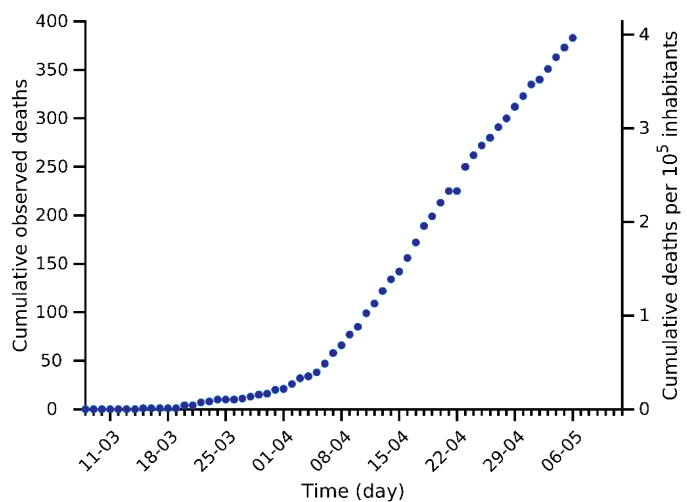
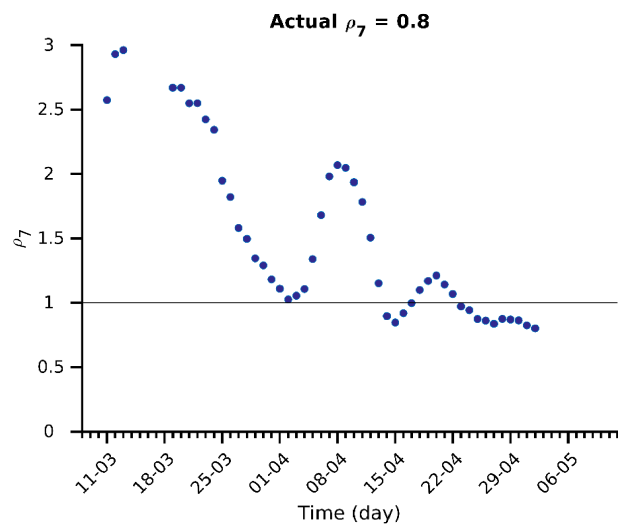
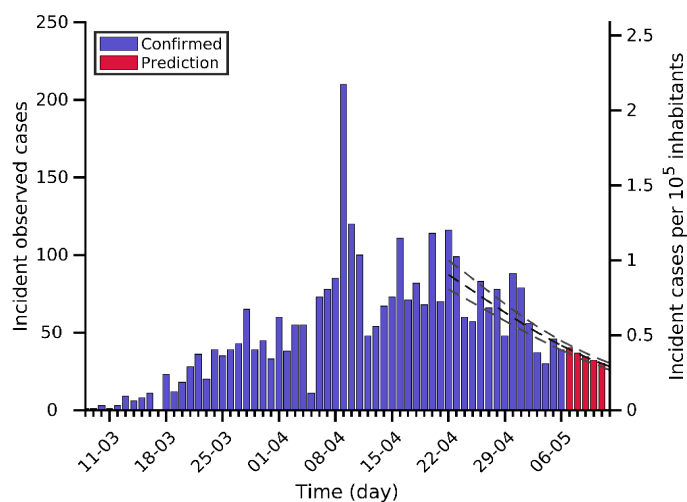
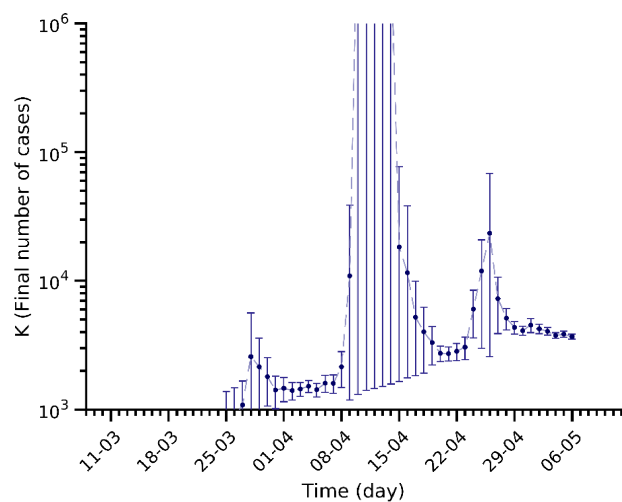
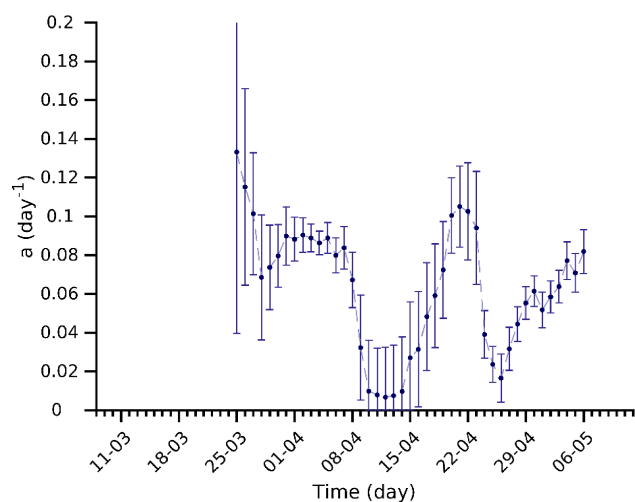
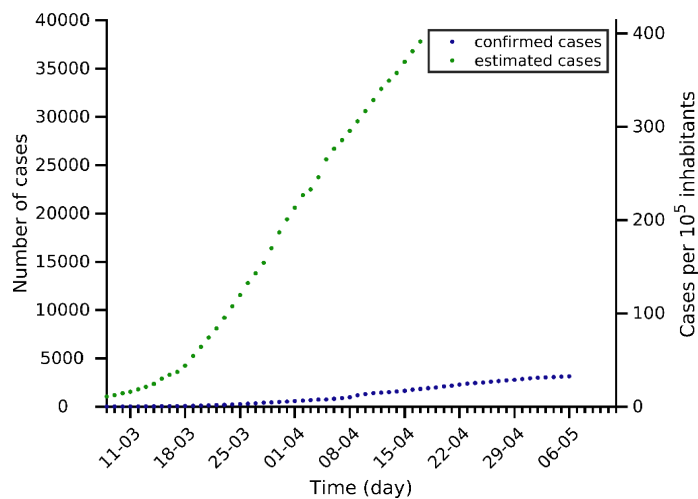
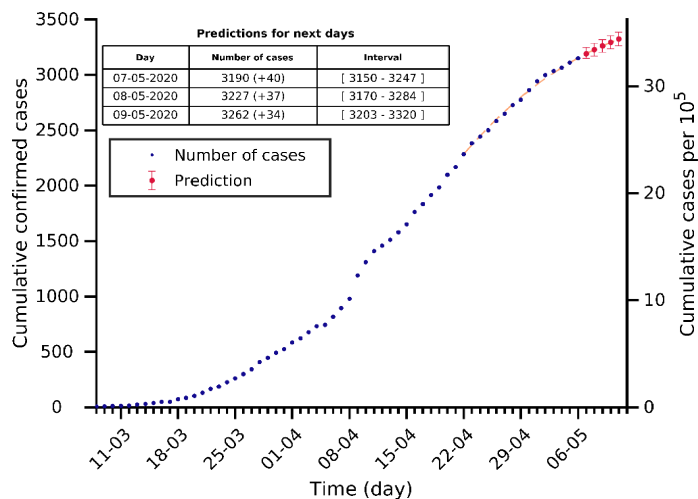
Finland 06-05-2020. Population: 5.5M. Current cumulated incidence: 101/10⁵



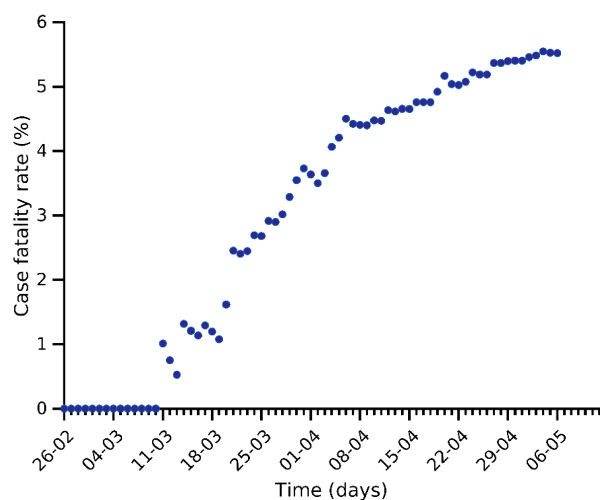
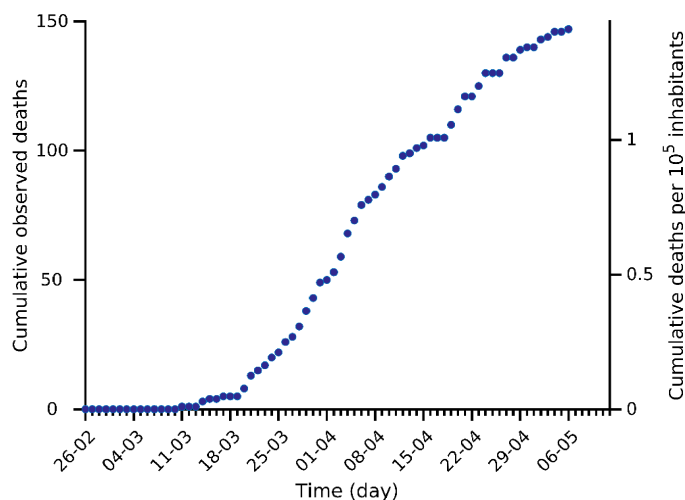
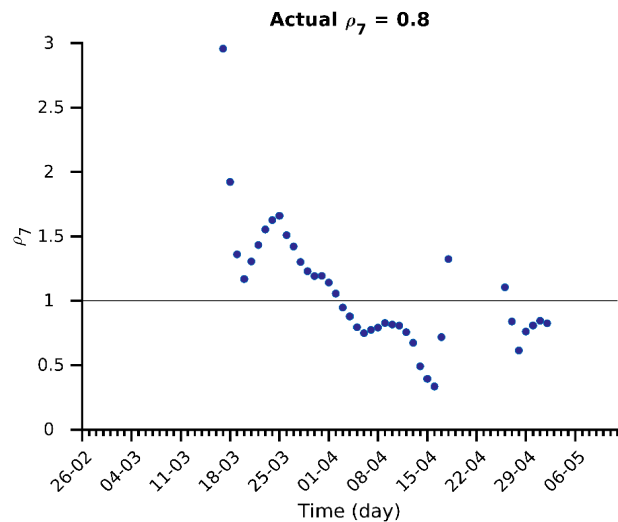
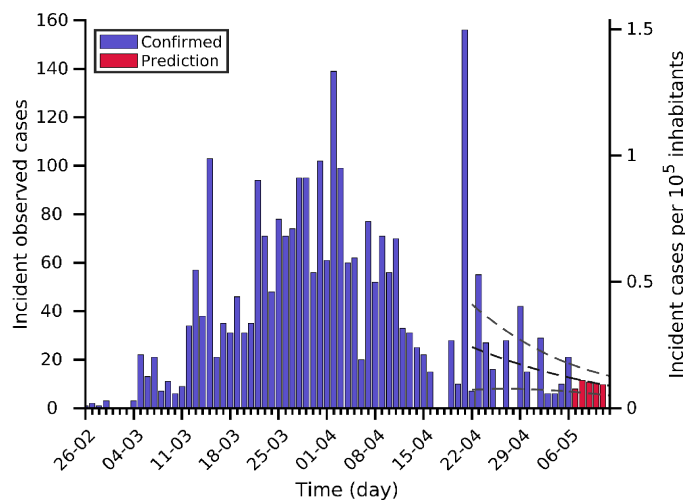
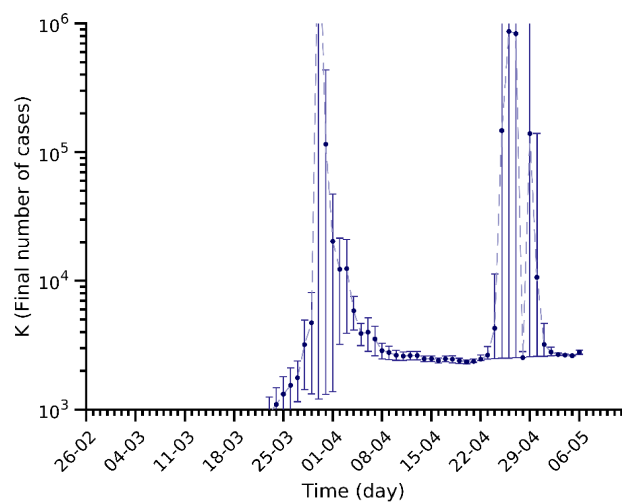
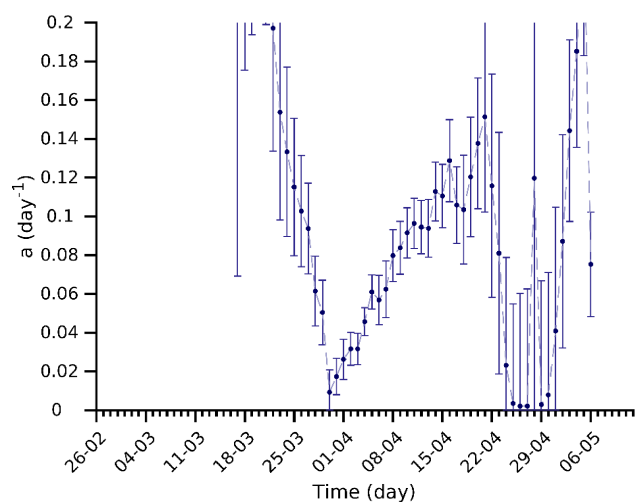
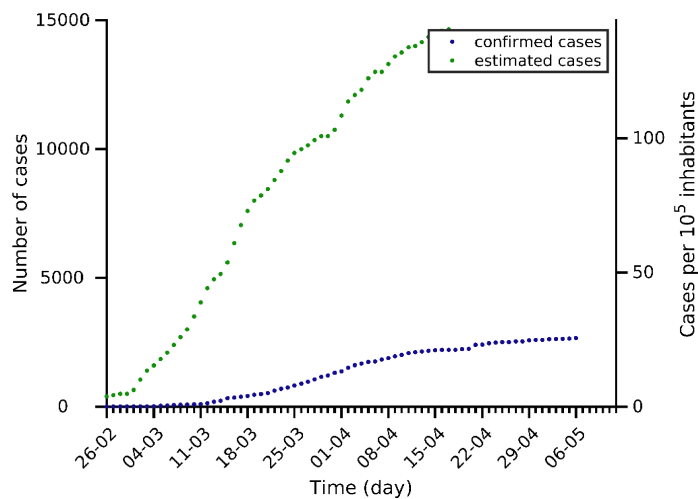
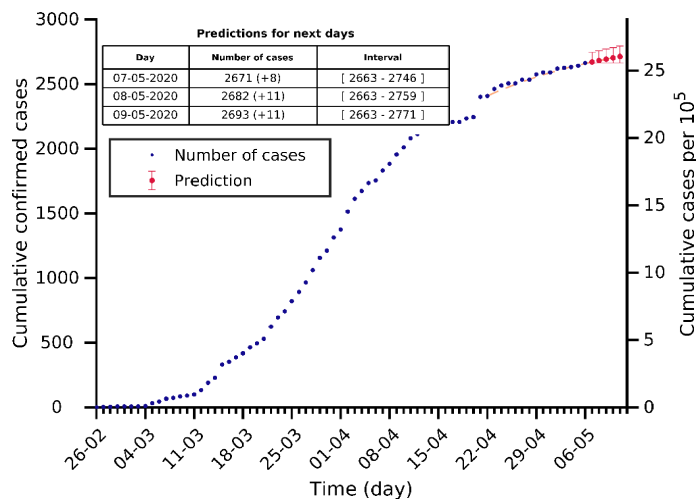
Luxembourg 06-05-2020. Population: 0.6M. Current cumulated incidence: 615/10⁵



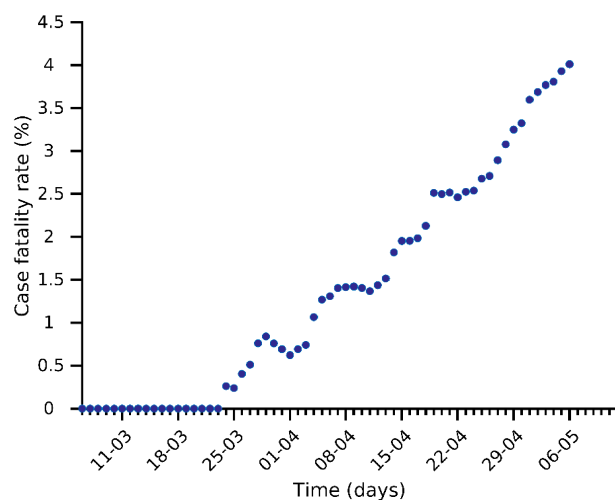
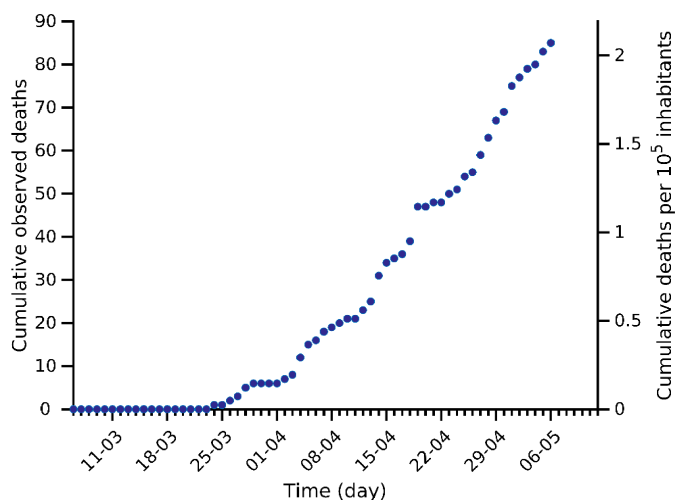
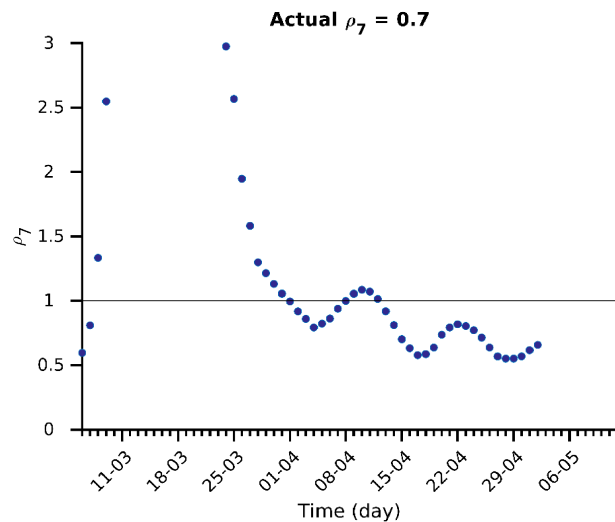
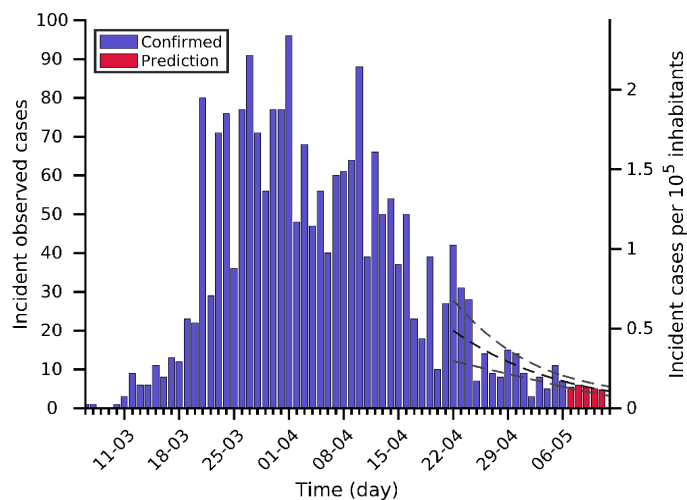
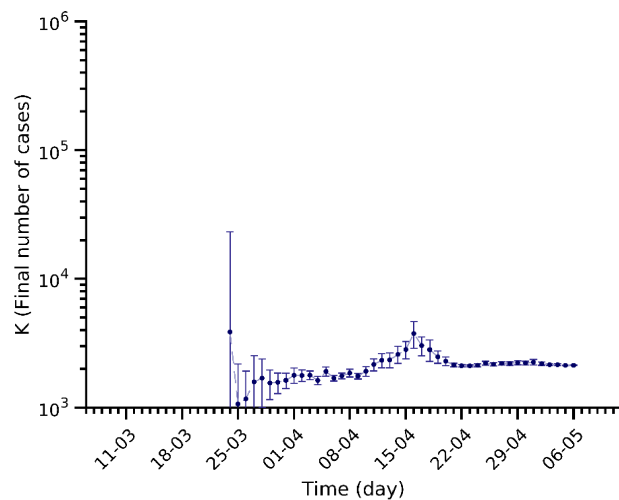
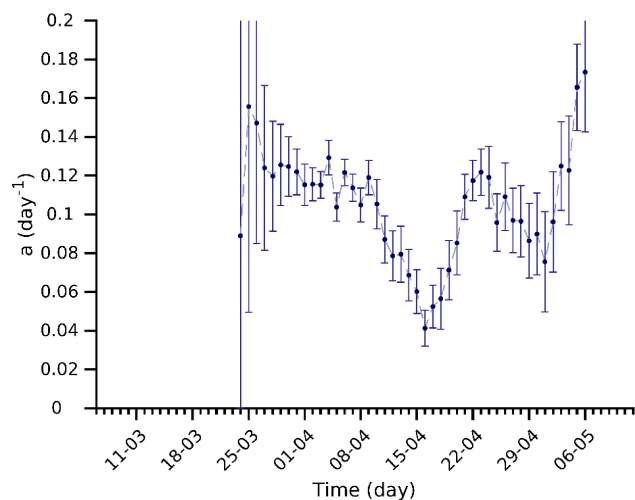
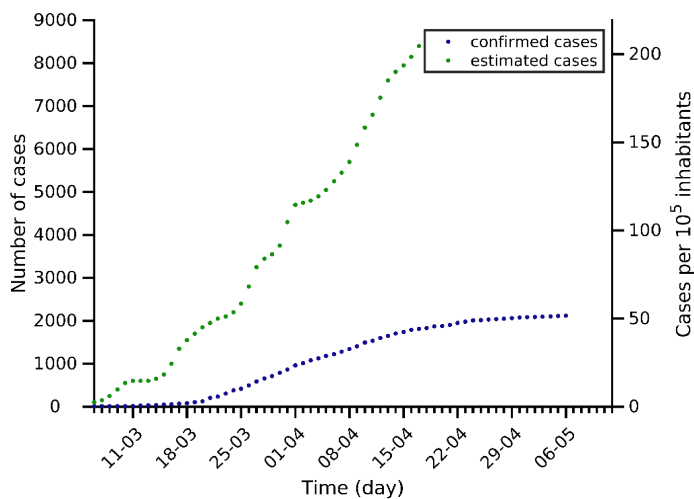
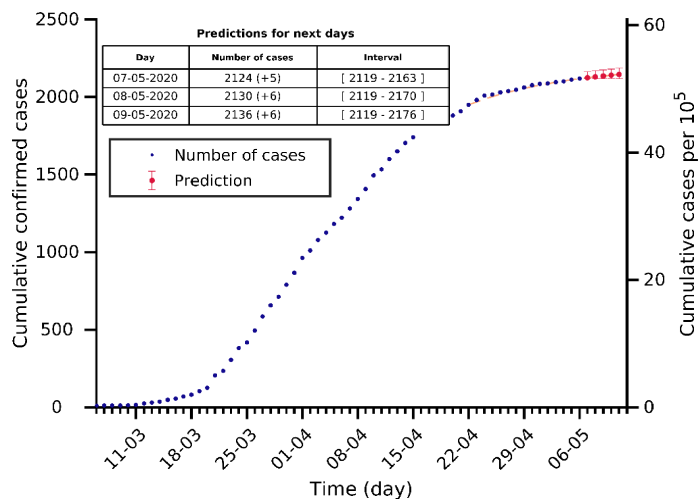
Hungary 06-05-2020. Population: 9.7M. Current cumulated incidence: 33/10⁵



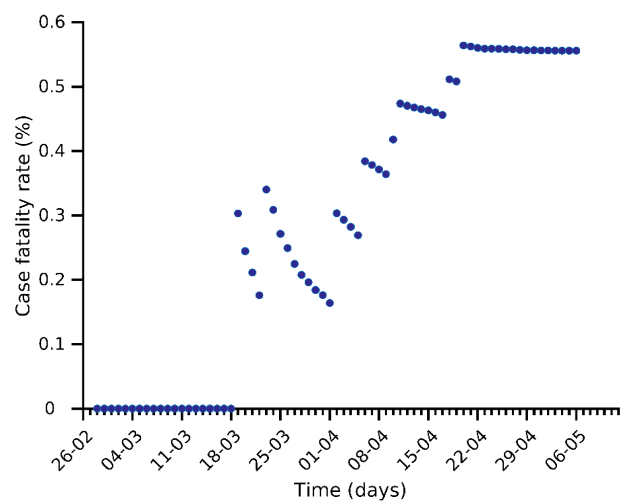
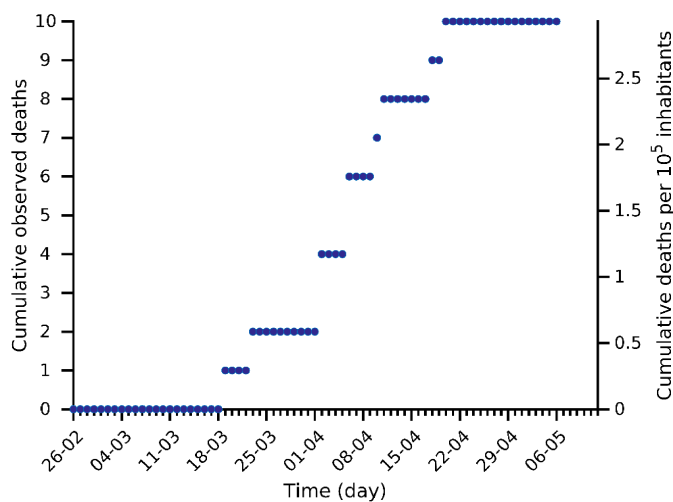
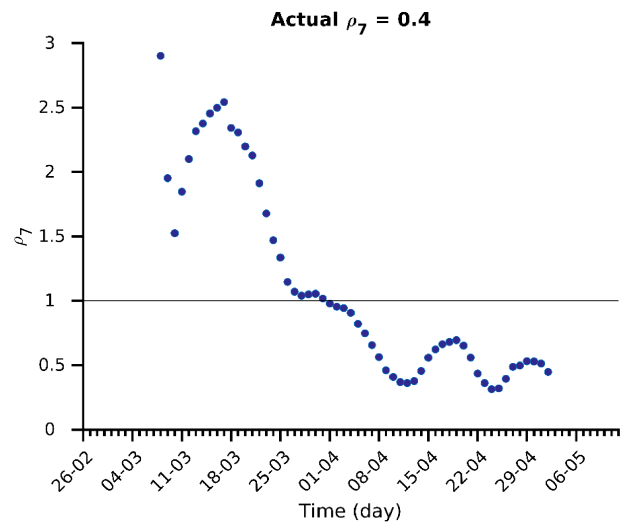
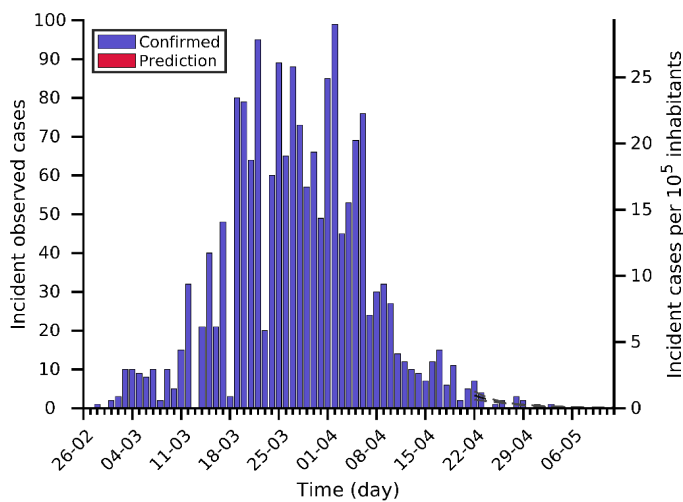
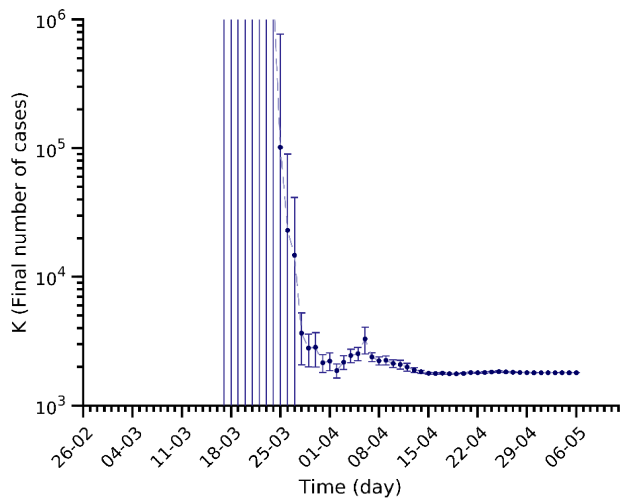
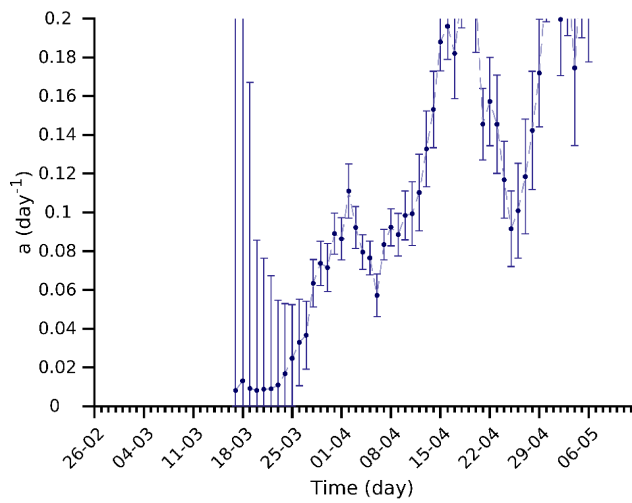
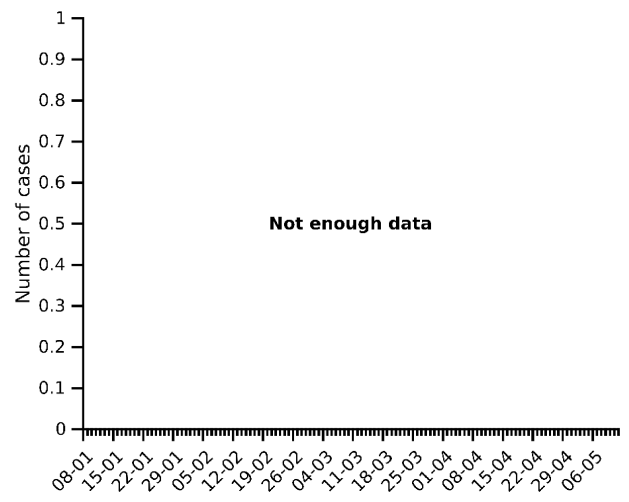
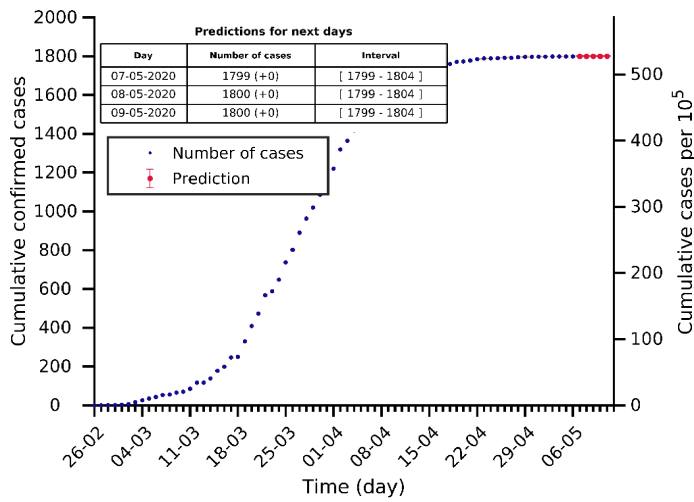
Greece 06-05-2020. Population: 10.4M. Current cumulated incidence: 26/10⁵



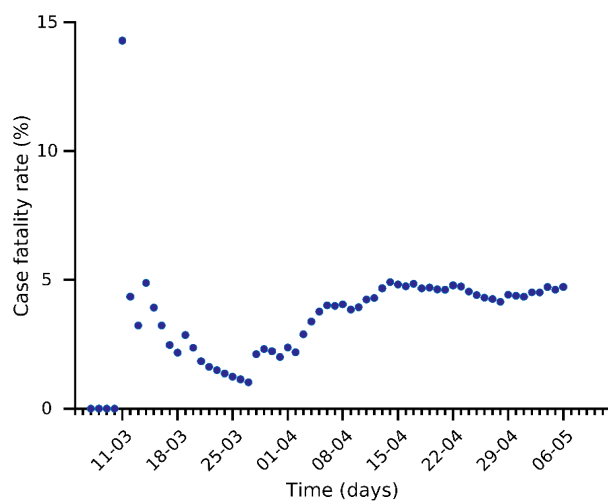
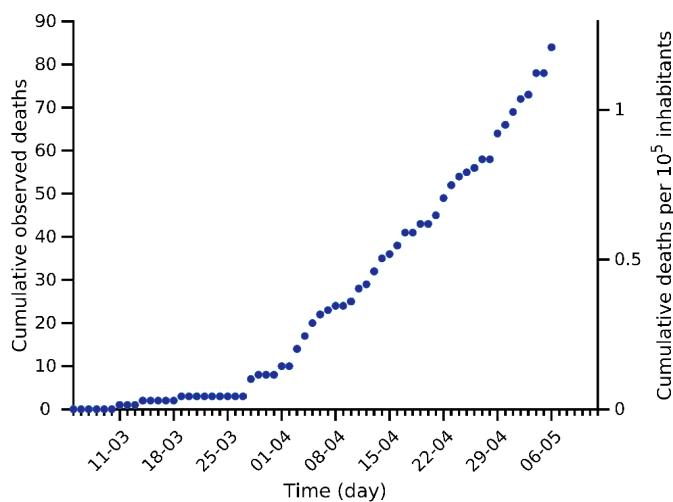
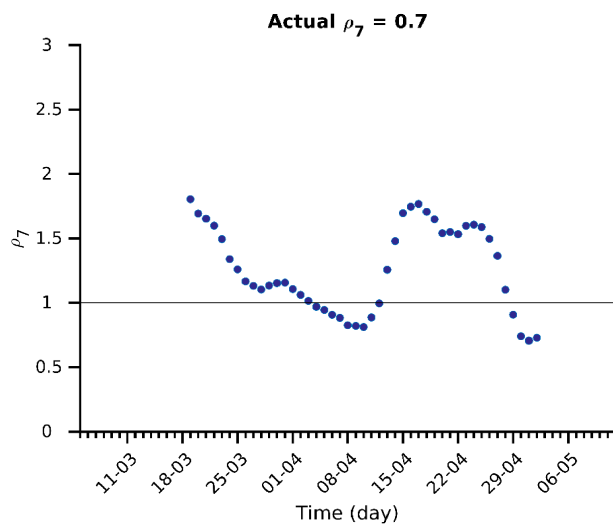
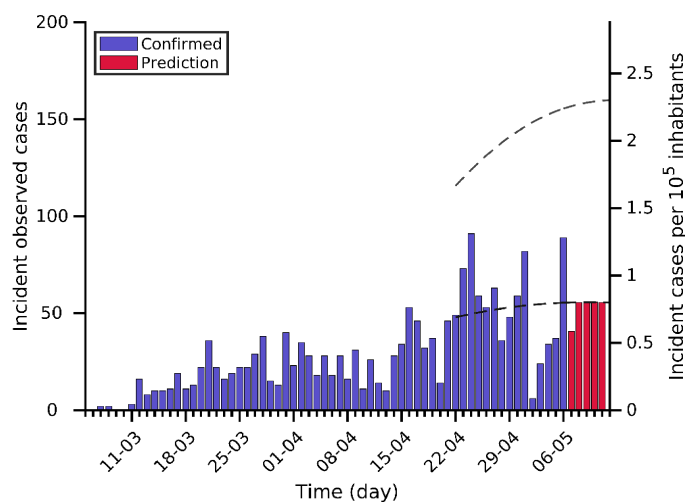
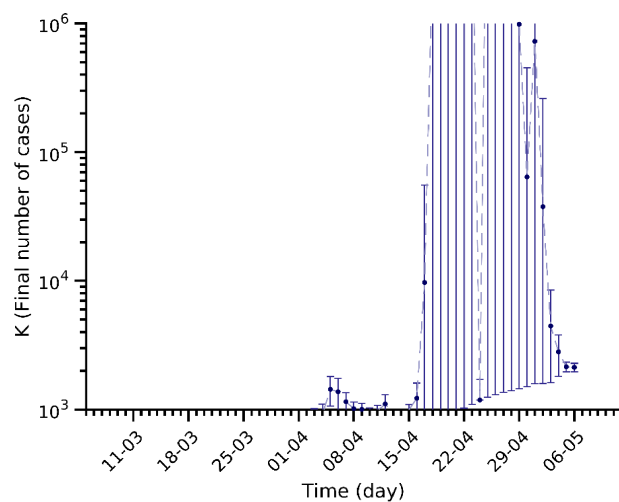
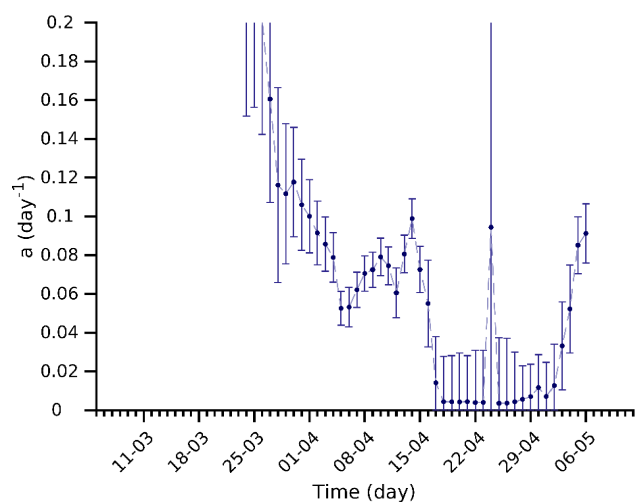
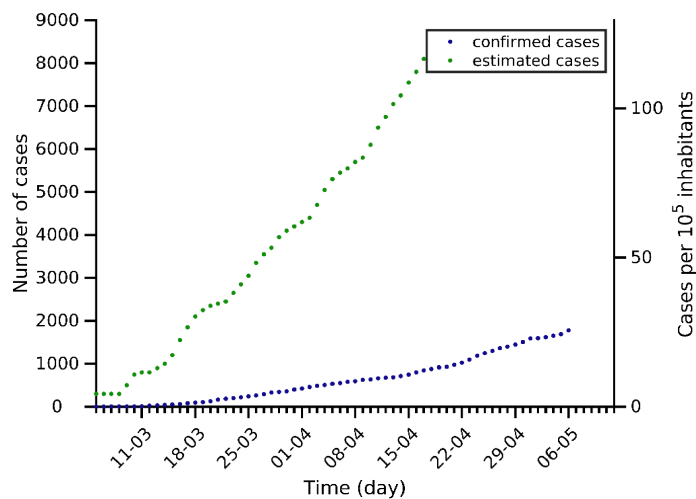
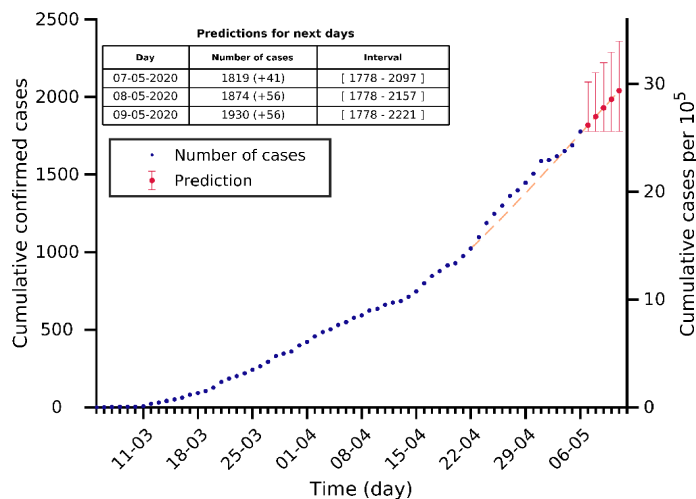
Croatia 06-05-2020. Population: 4.1M. Current cumulated incidence: 52/10⁵



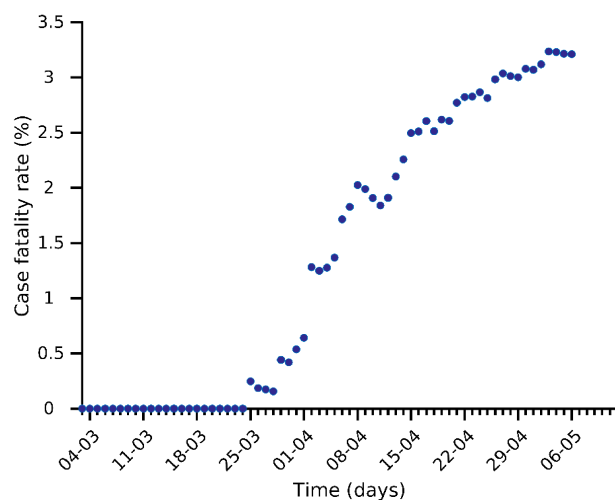
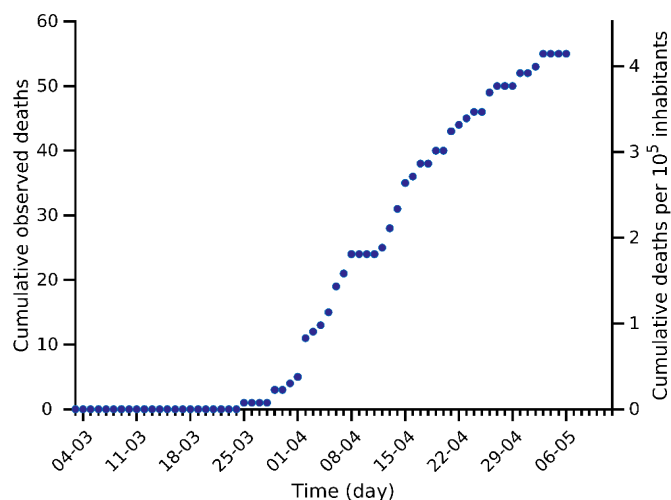
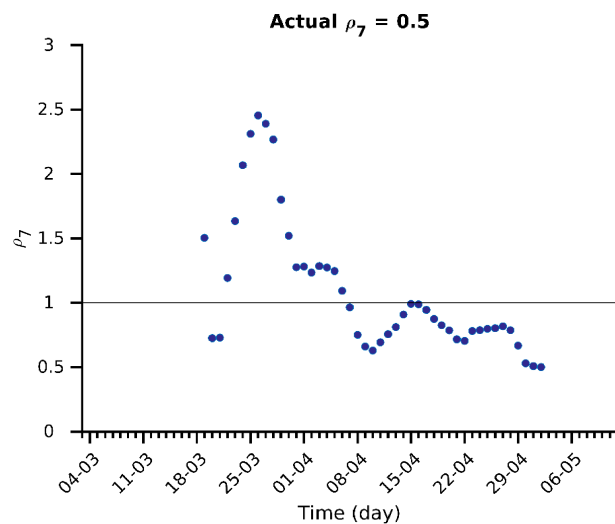
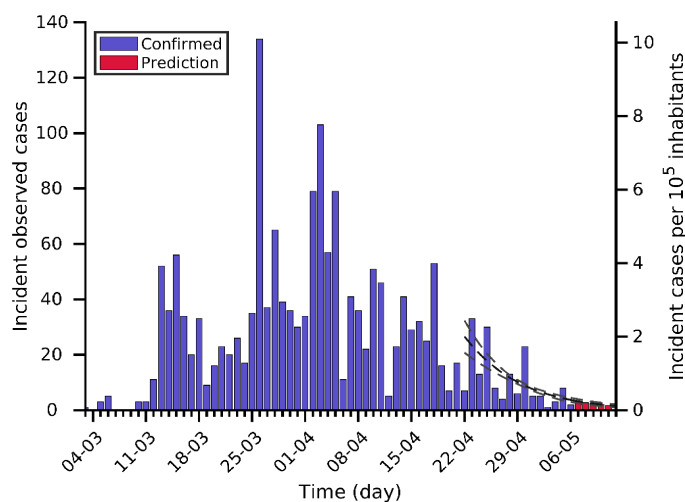
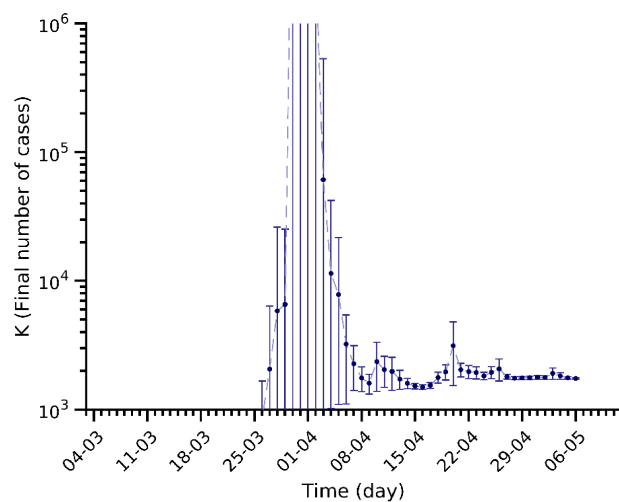
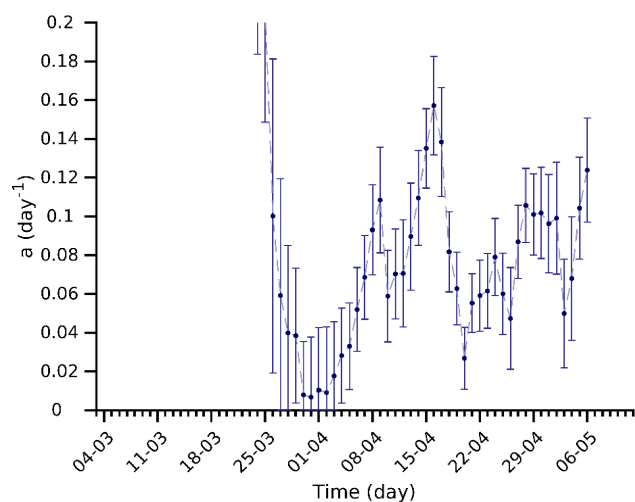
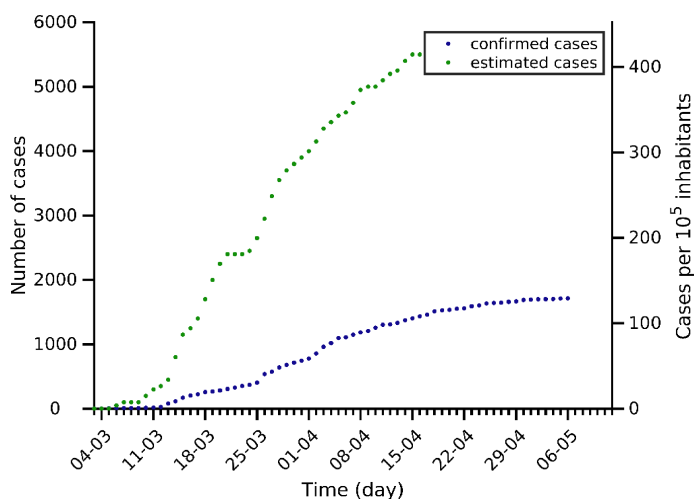
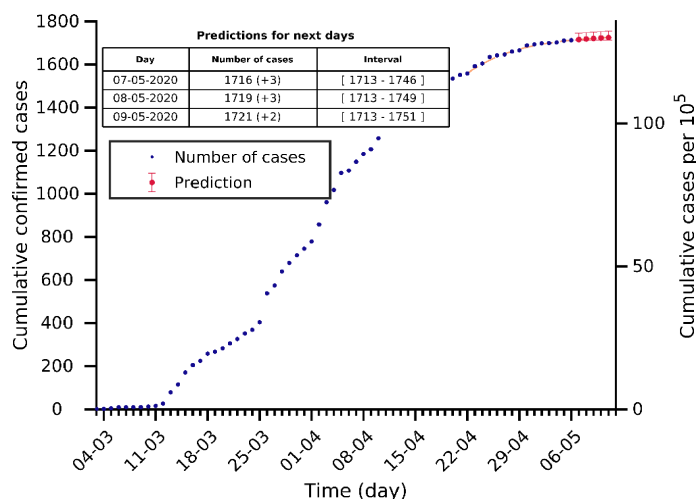
Iceland 06-05-2020. Population: 0.3M. Current cumulated incidence: 527/10⁵



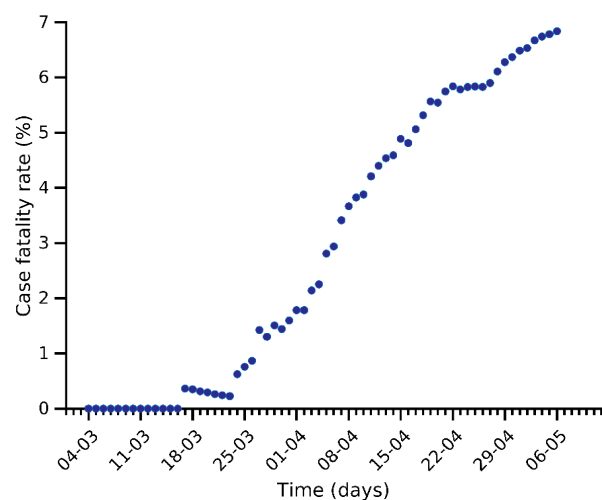
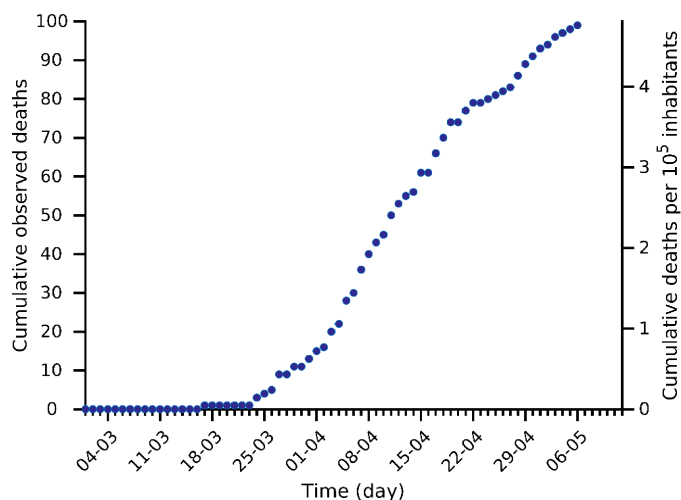
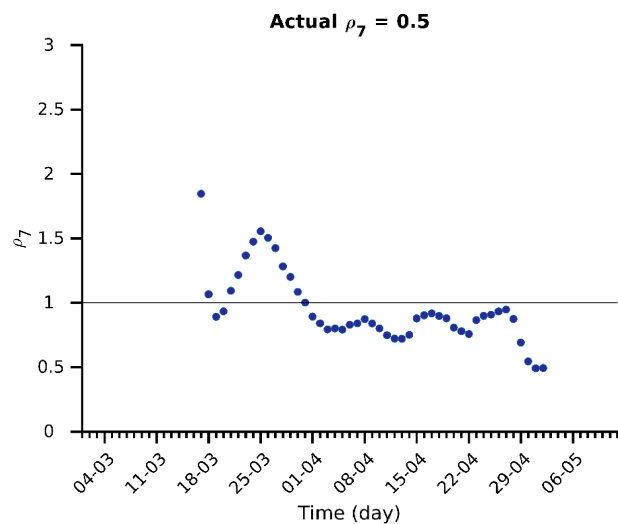
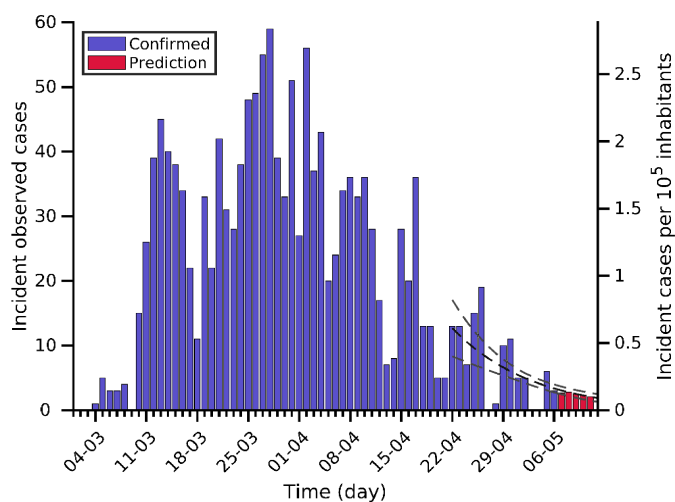
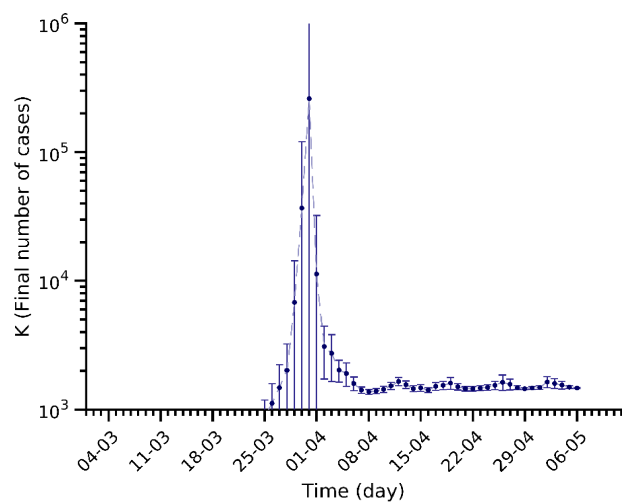
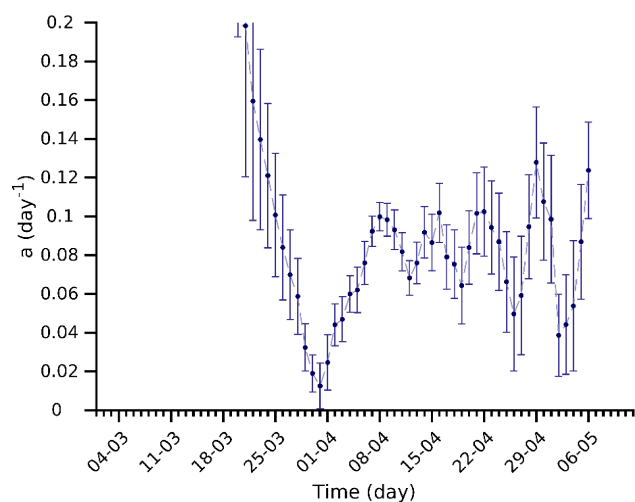
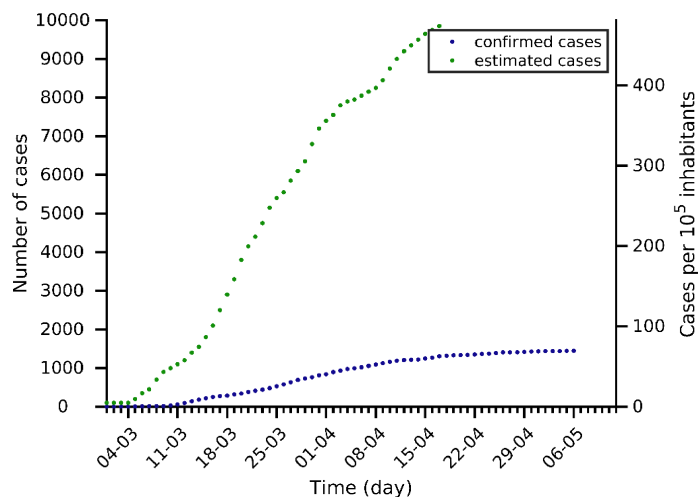
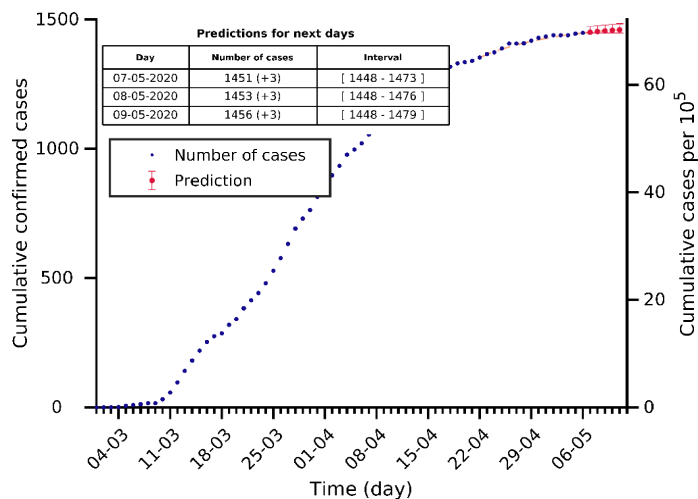
Bulgaria 06-05-2020. Population: 6.9M. Current cumulated incidence: 26/10⁵



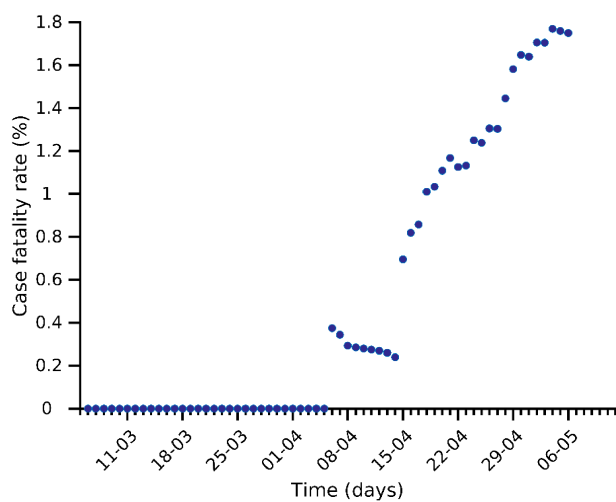
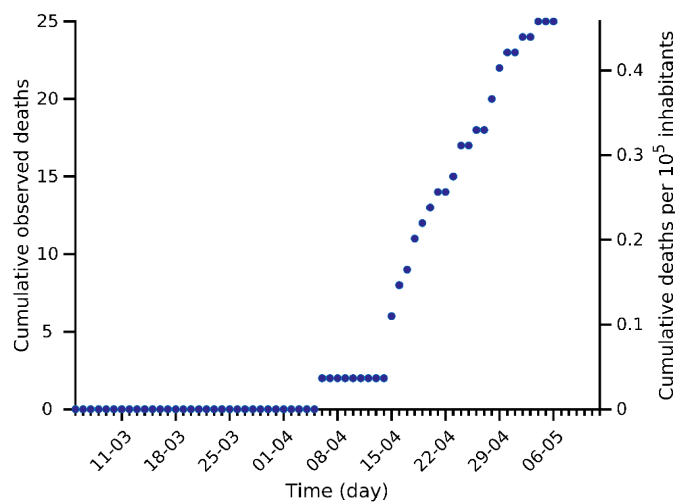
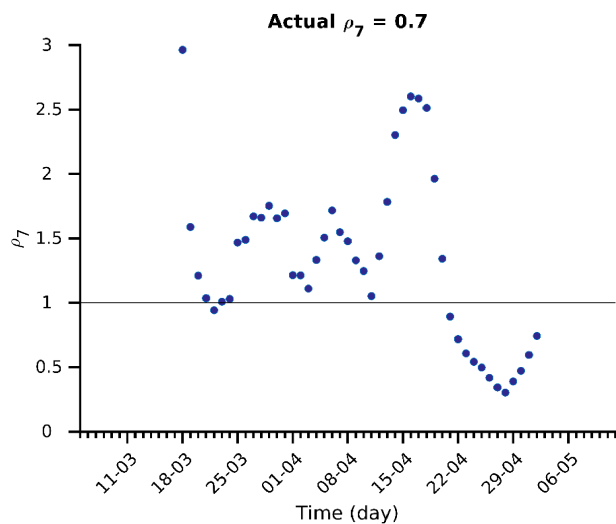
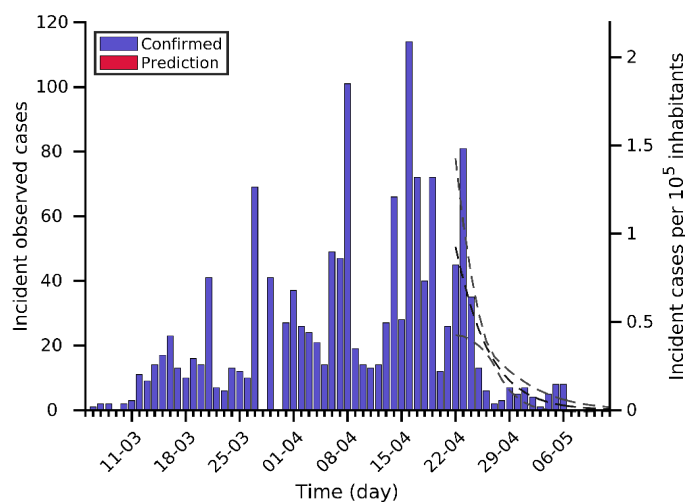
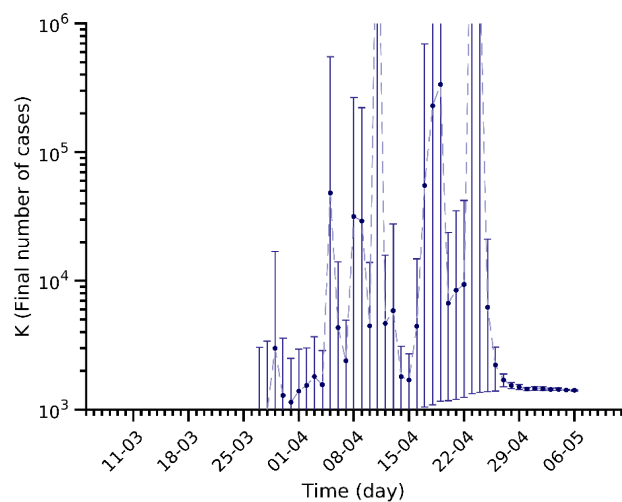
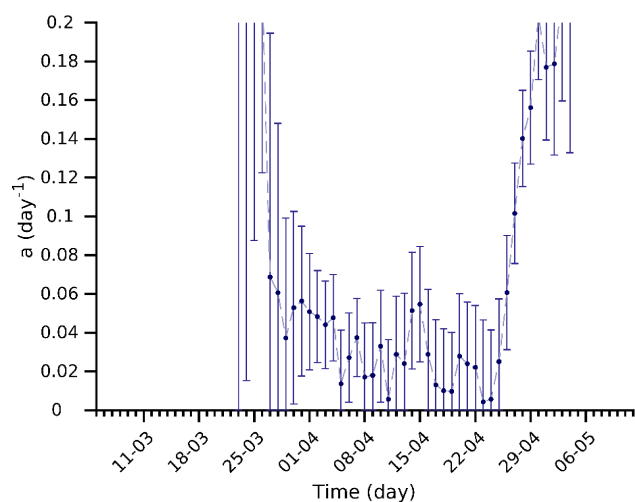
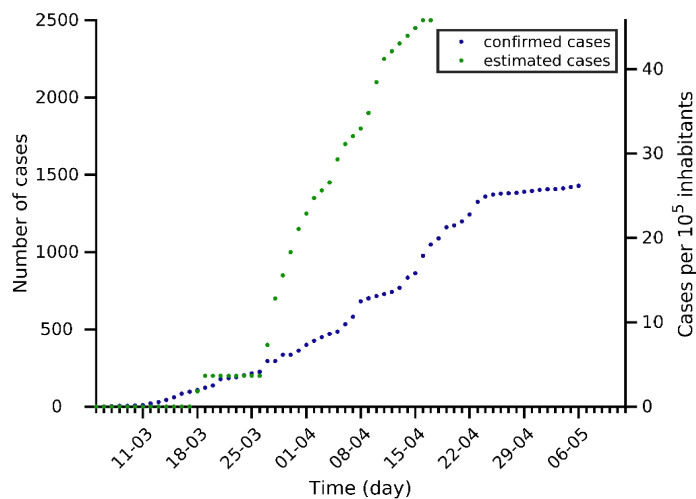
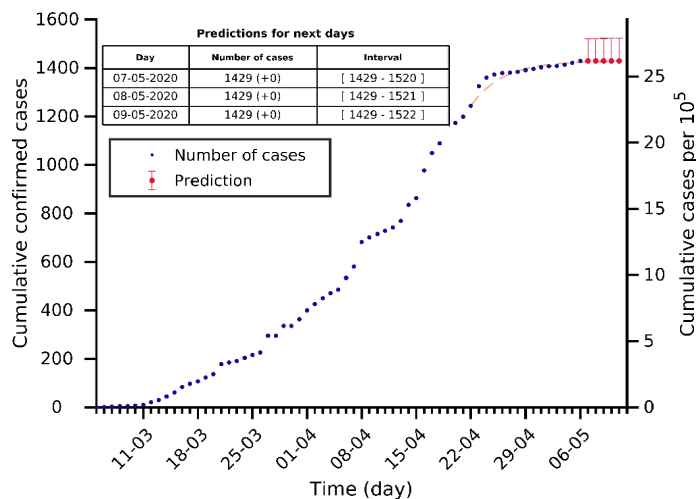
Estonia 06-05-2020. Population: 1.3M. Current cumulated incidence: 129/10⁵



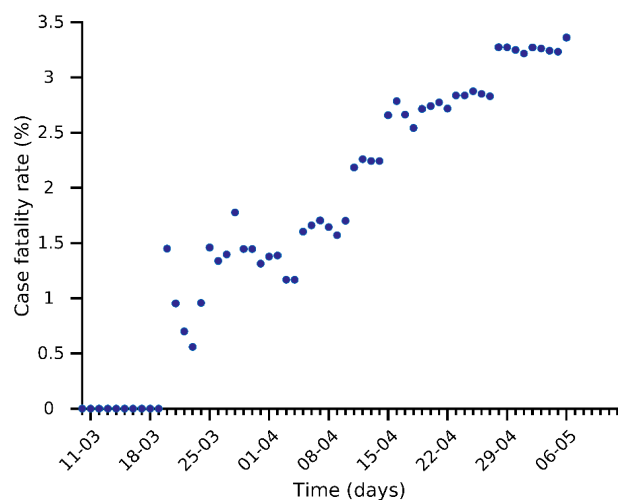
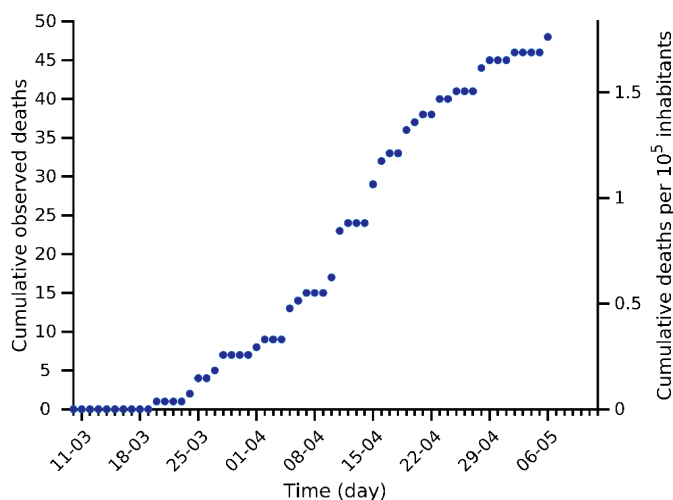
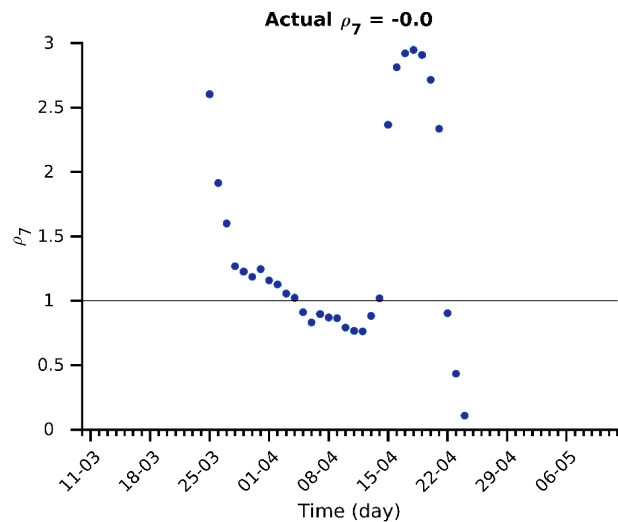
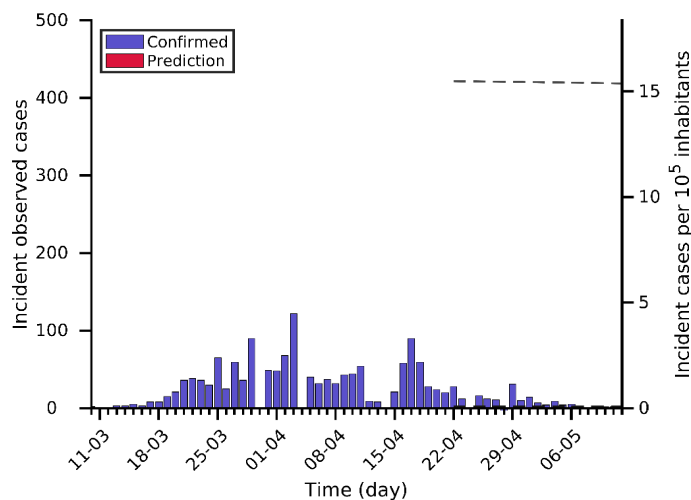
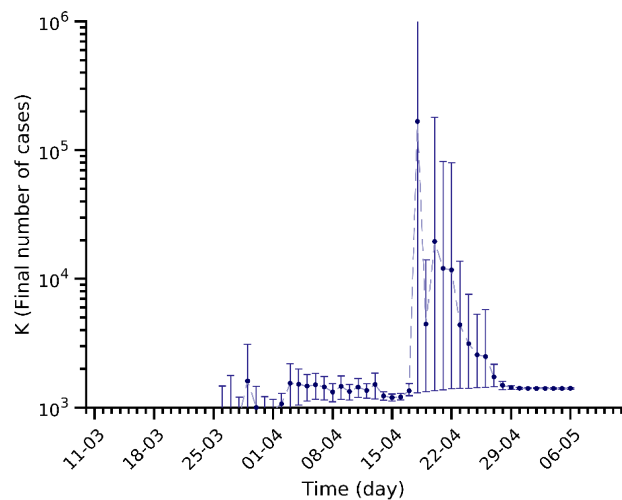
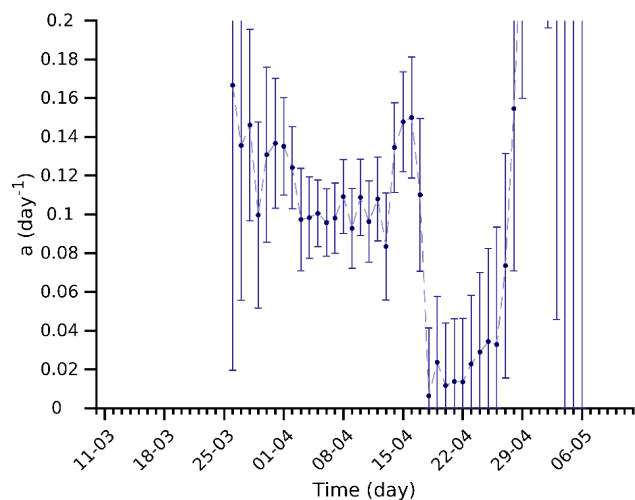
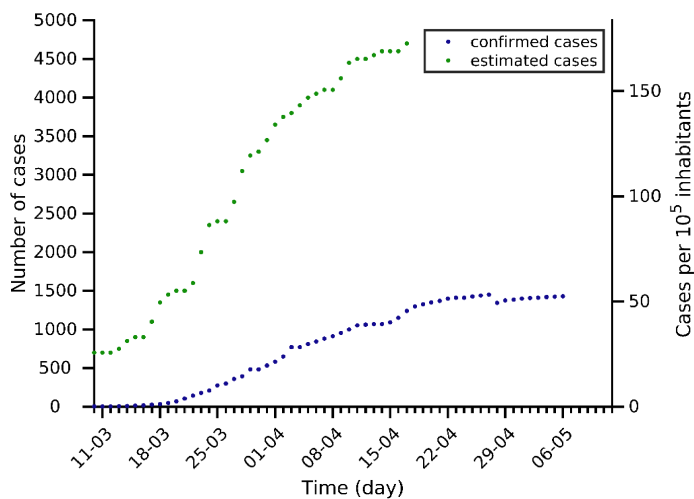
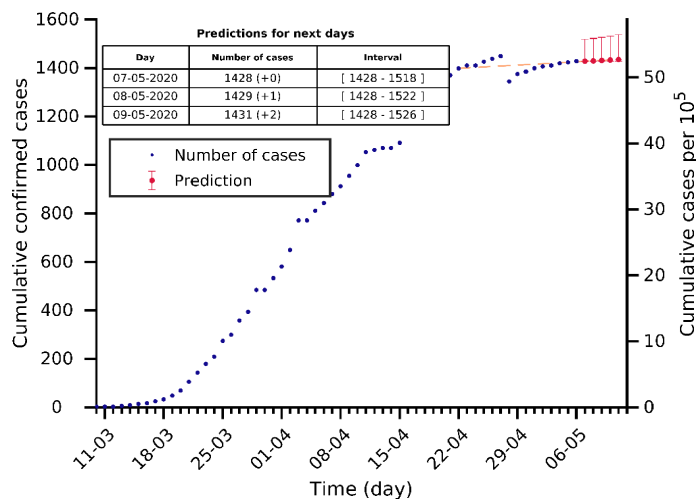
Slovenia 06-05-2020. Population: 2.1M. Current cumulated incidence: 70/10⁵



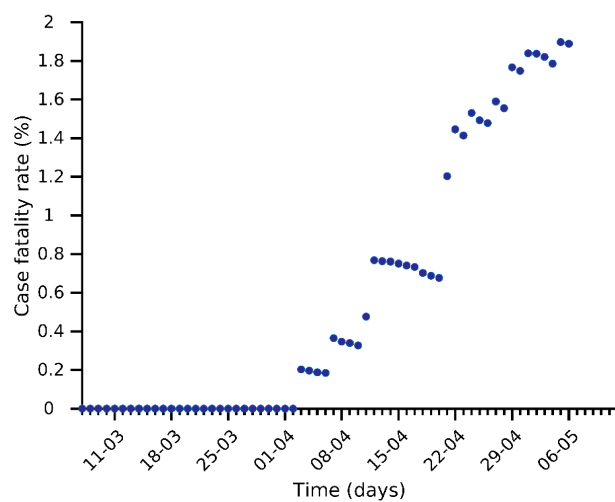
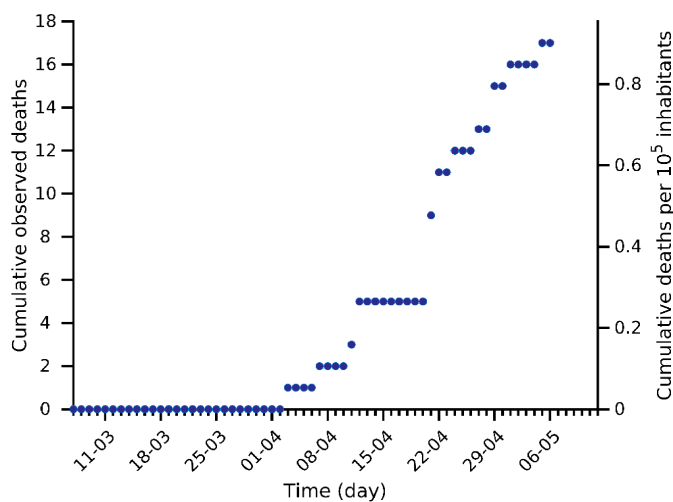
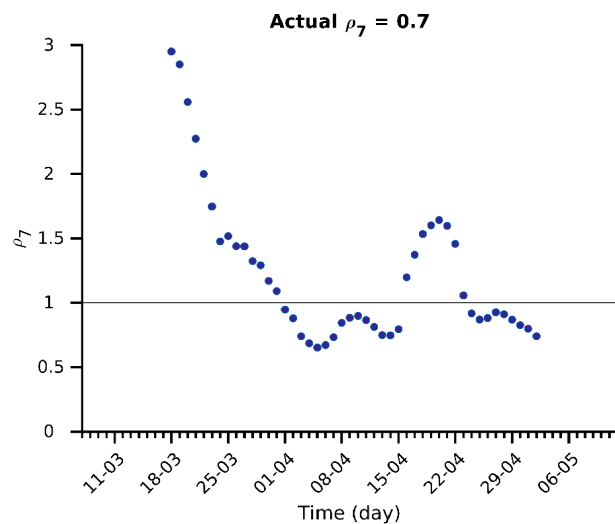
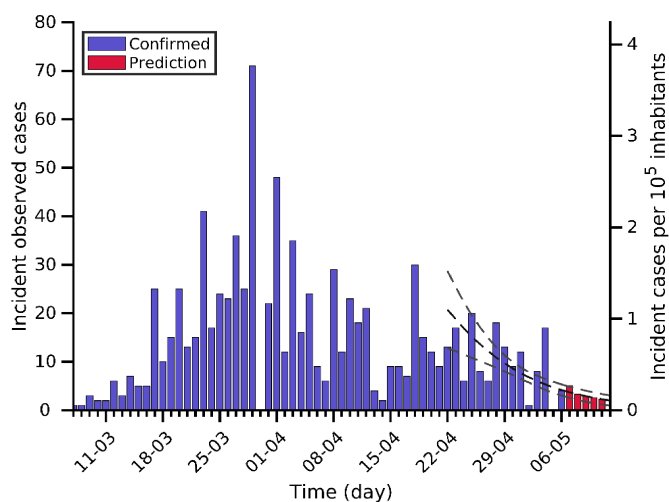
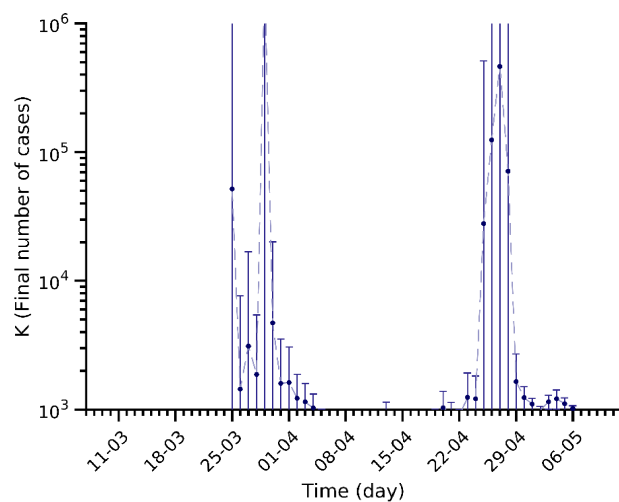
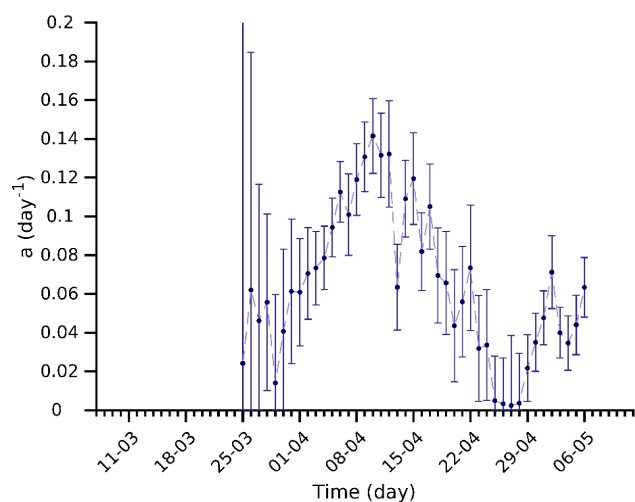
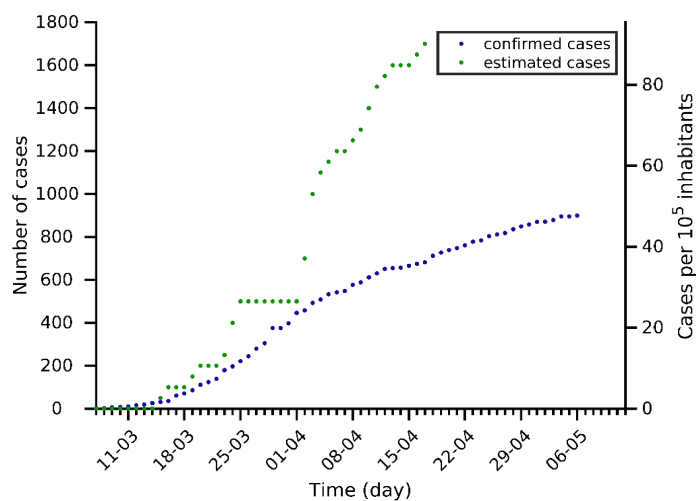
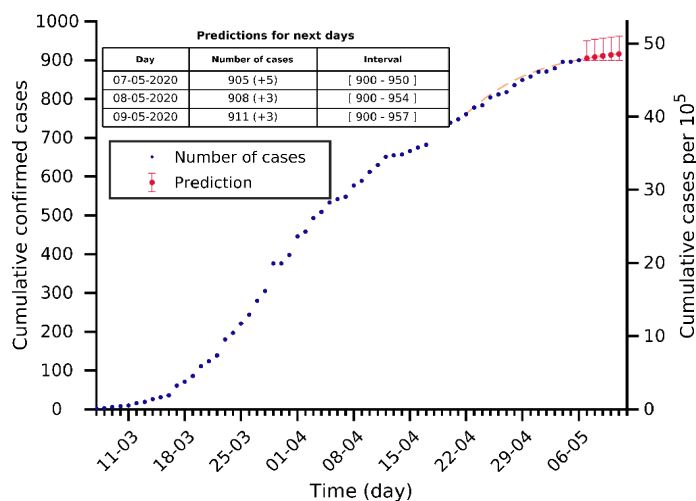
Slovakia 06-05-2020. Population: 5.5M. Current cumulated incidence: 26/10⁵



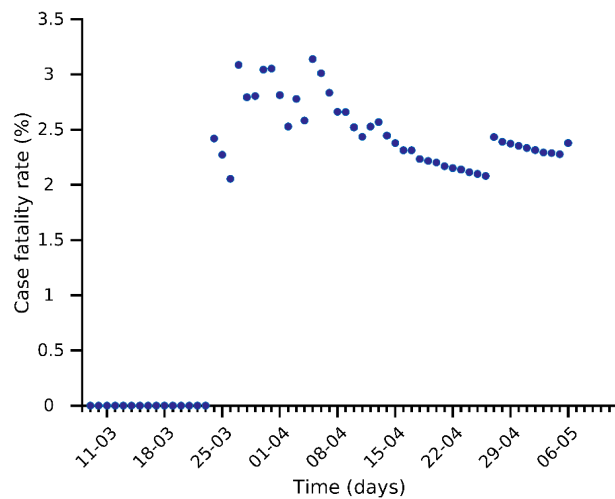
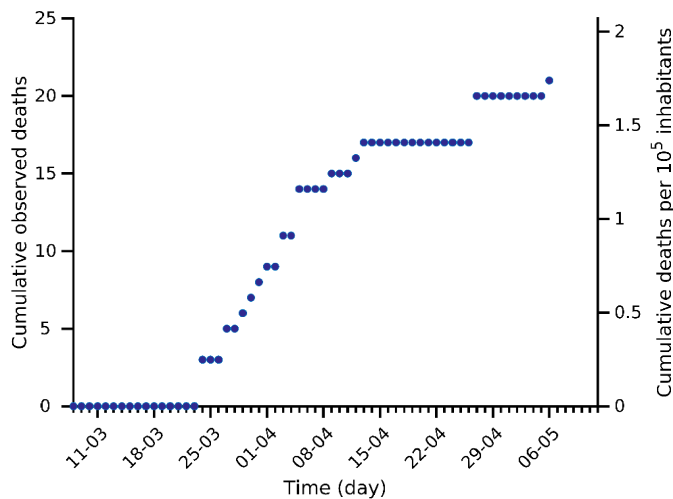
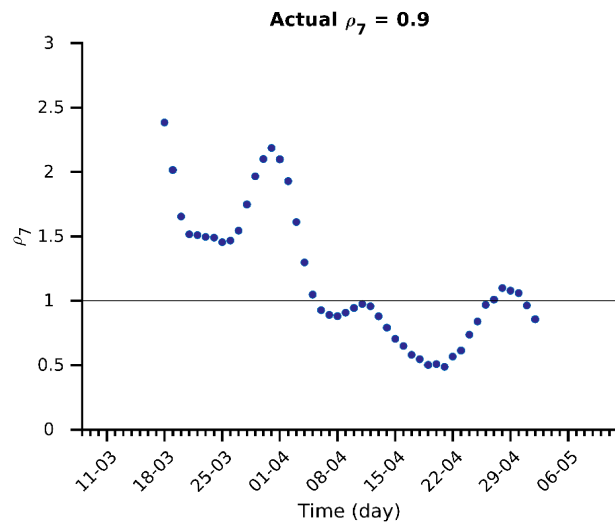
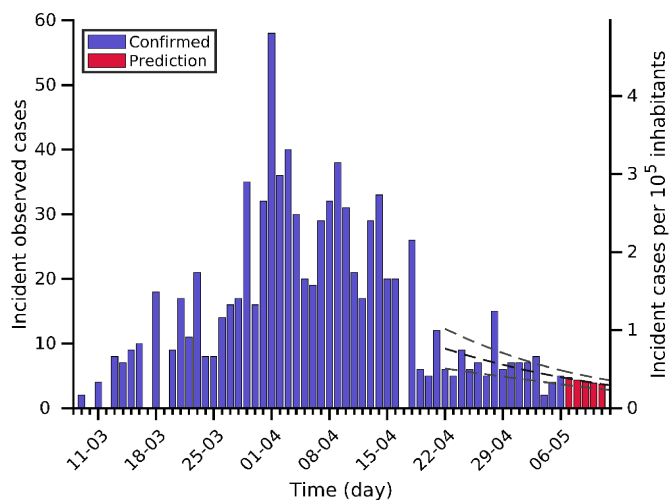
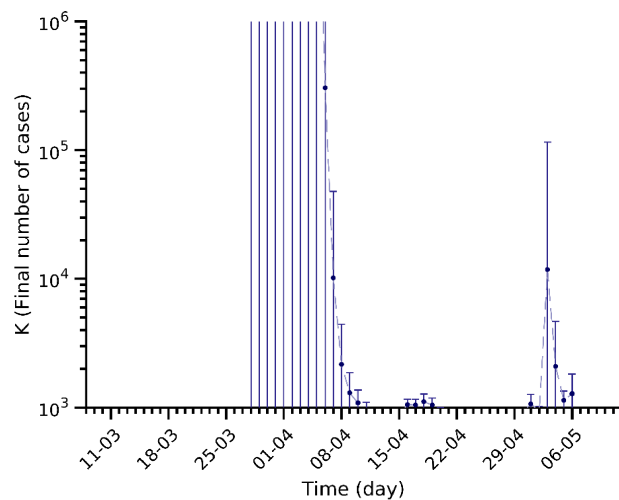
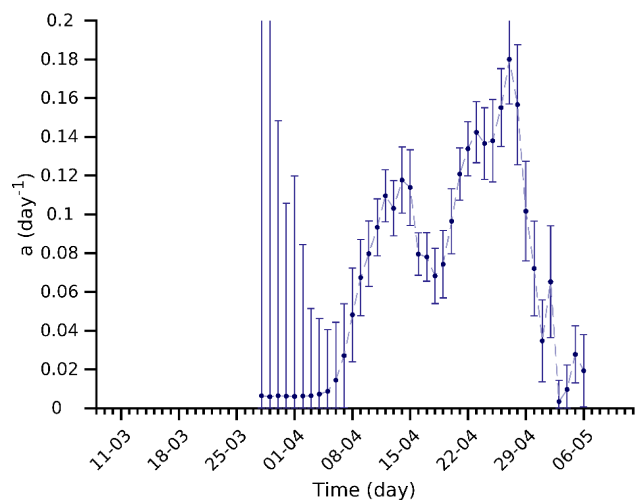
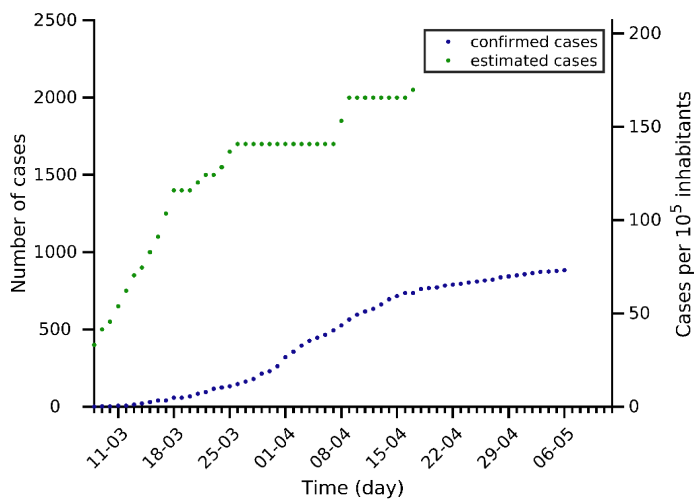
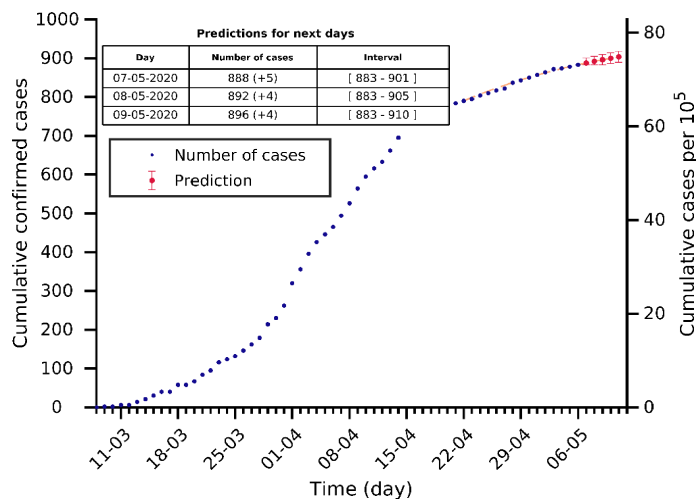
Lithuania 06-05-2020. Population: 2.7M. Current cumulated incidence: 52/10⁵



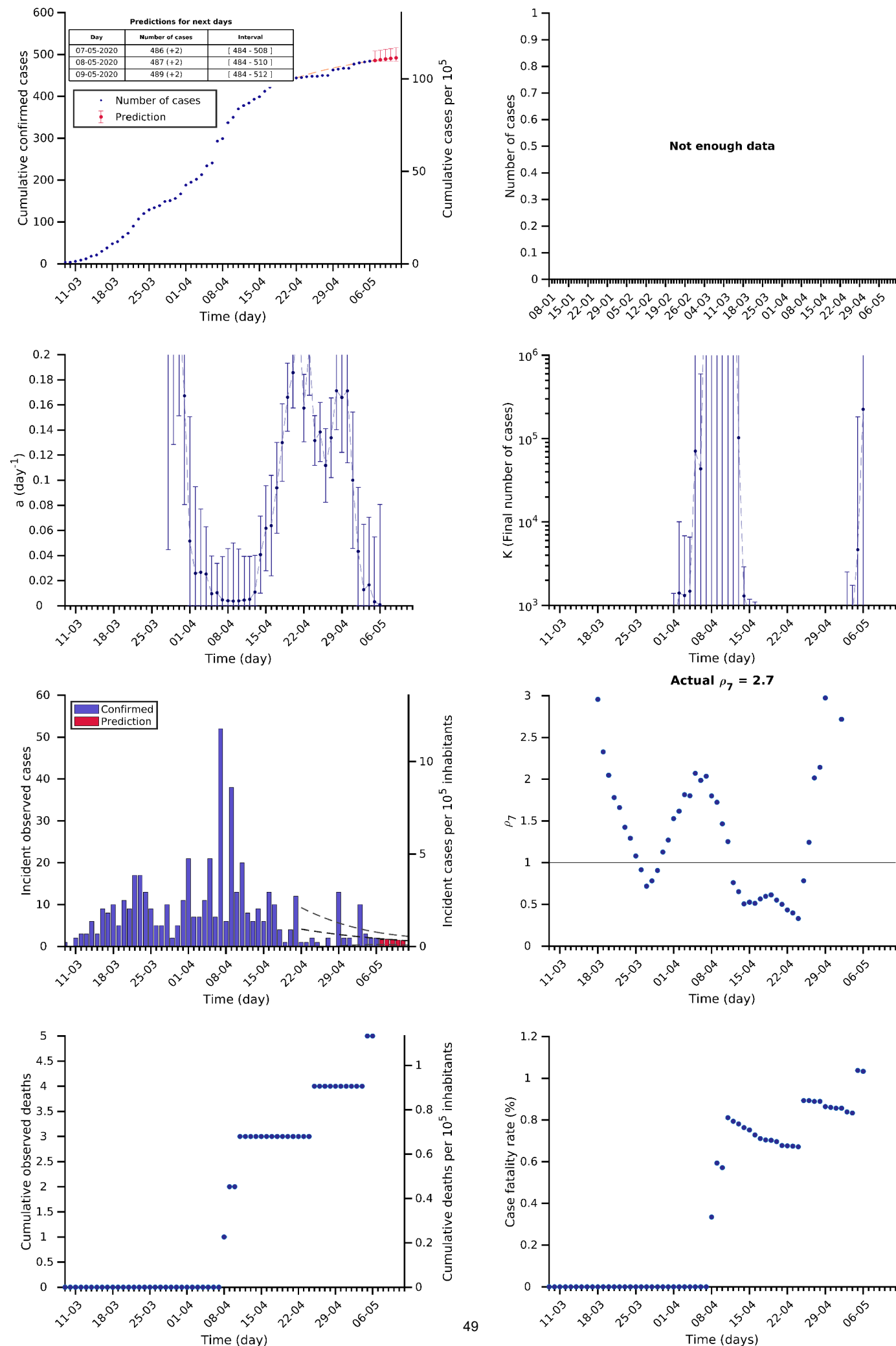
Latvia 06-05-2020. Population: 1.9M. Current cumulated incidence: 48/10⁵



Cyprus 06-05-2020. Population: 1.2M. Current cumulated incidence: 73/10⁵



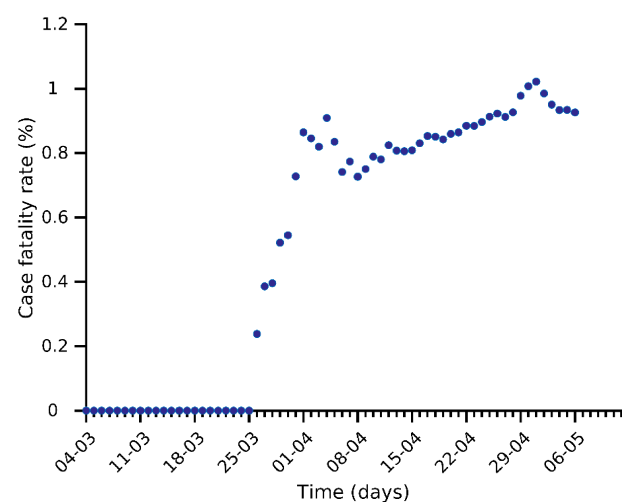
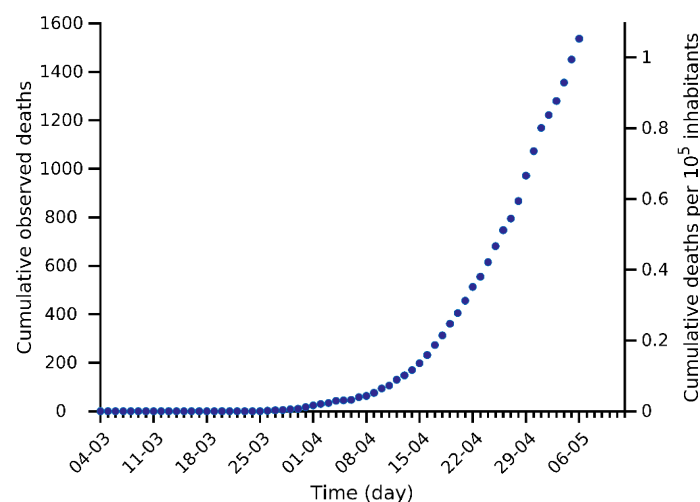
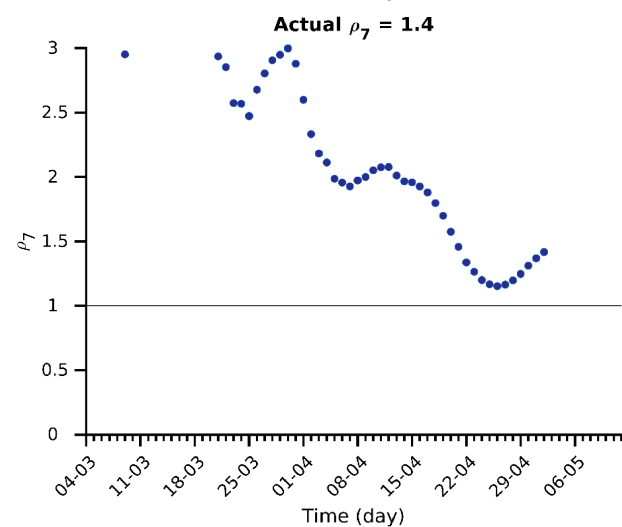
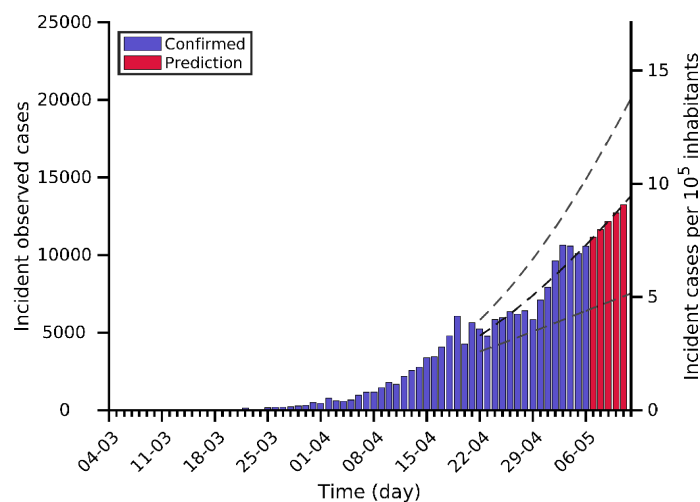
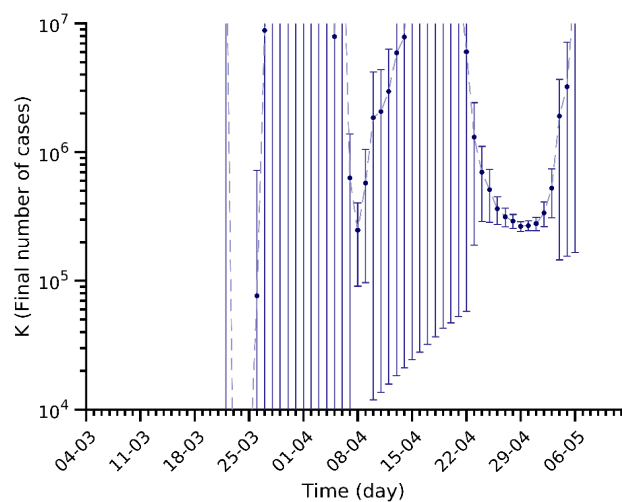
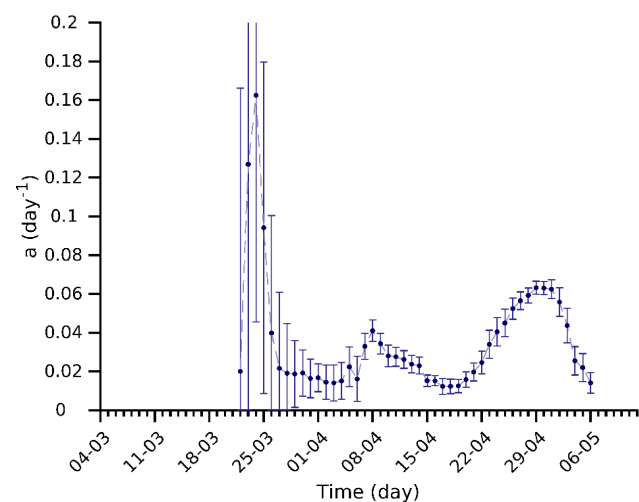
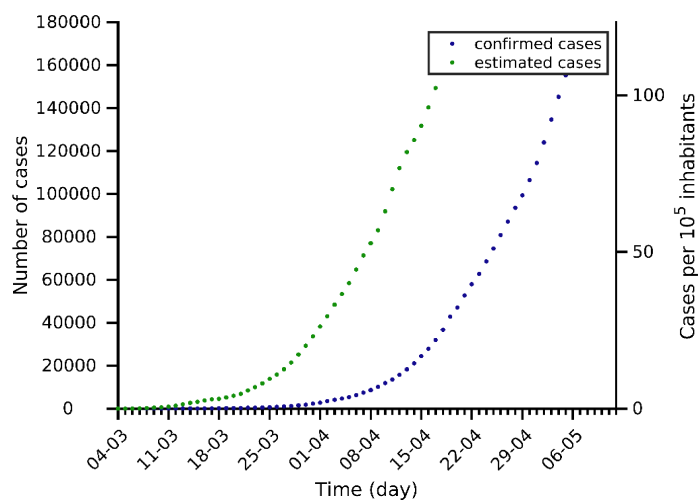
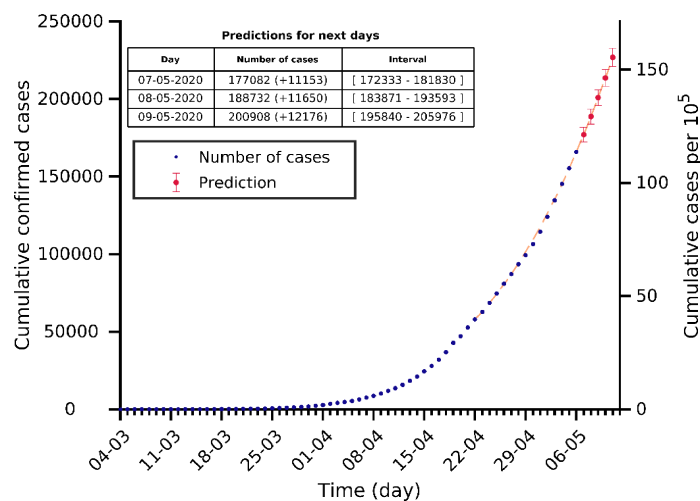
Malta 06-05-2020. Population: 0.4M. Current cumulated incidence: 110/10⁵



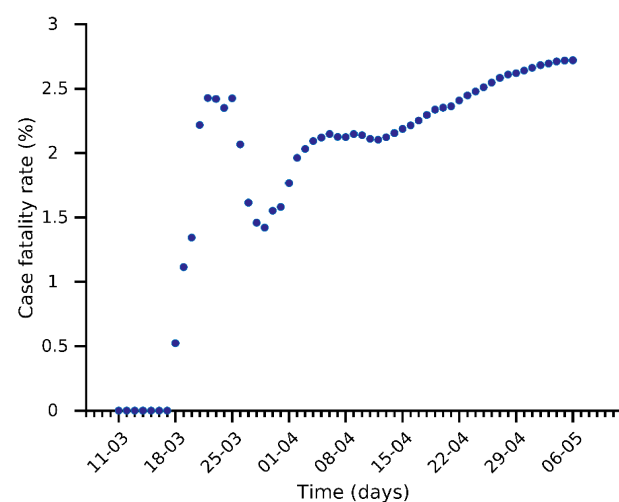
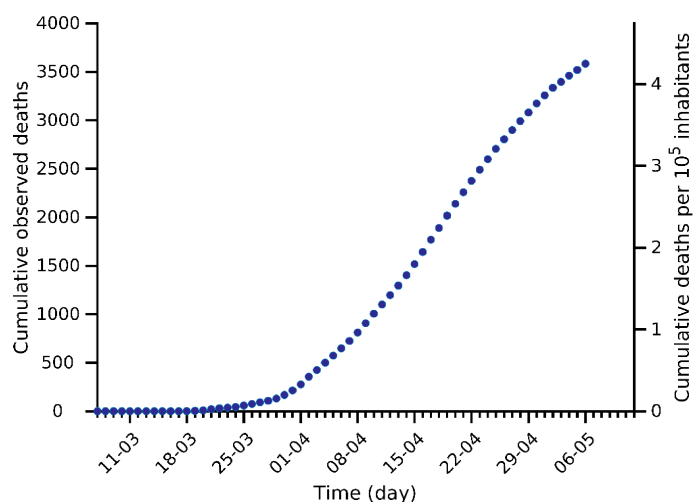
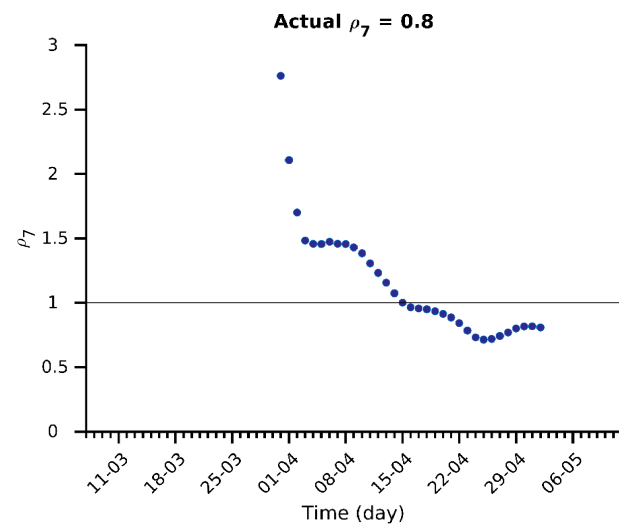
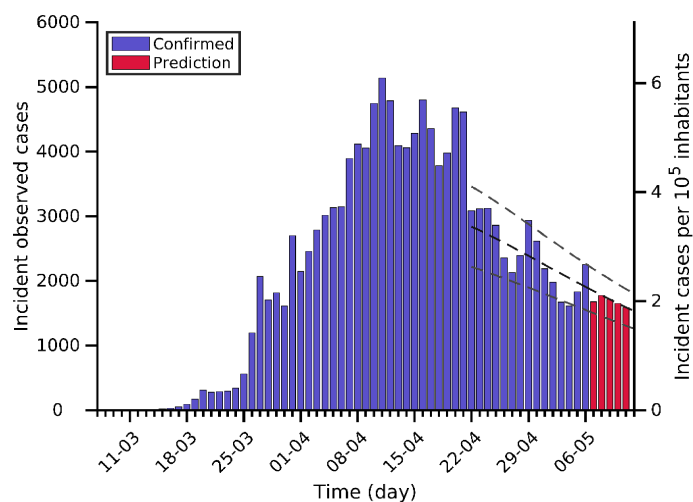
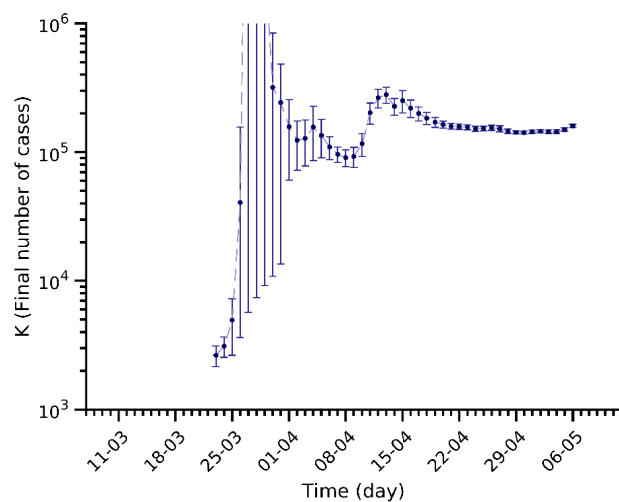
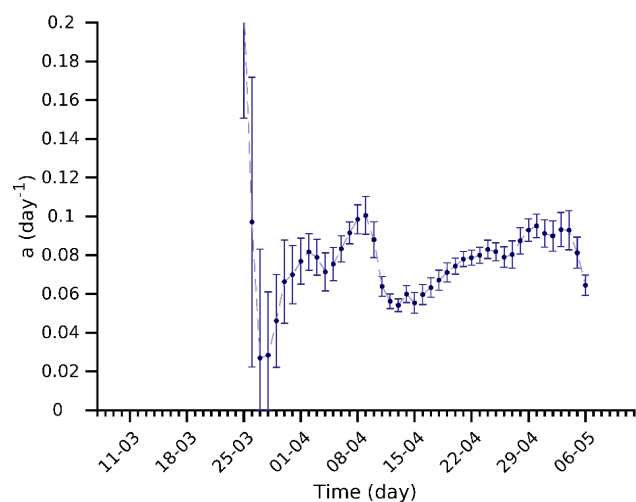
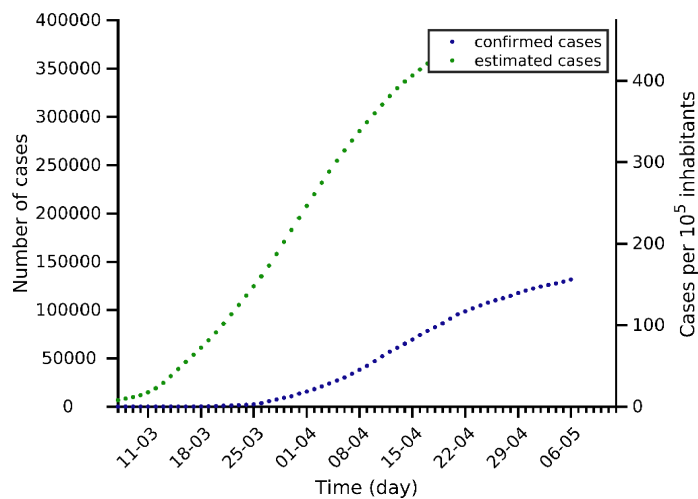
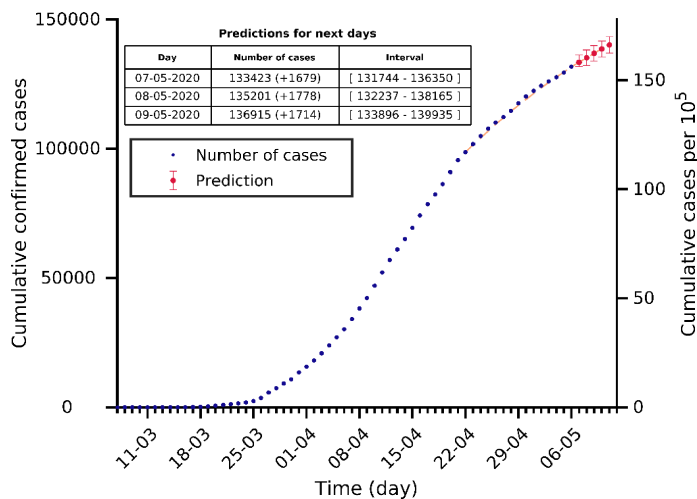
(2) Analysis and prediction of COVID-19 for other countries

Data obtained from <https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases>

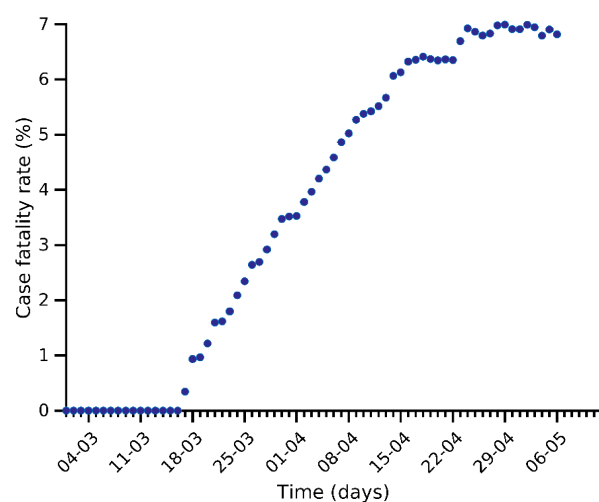
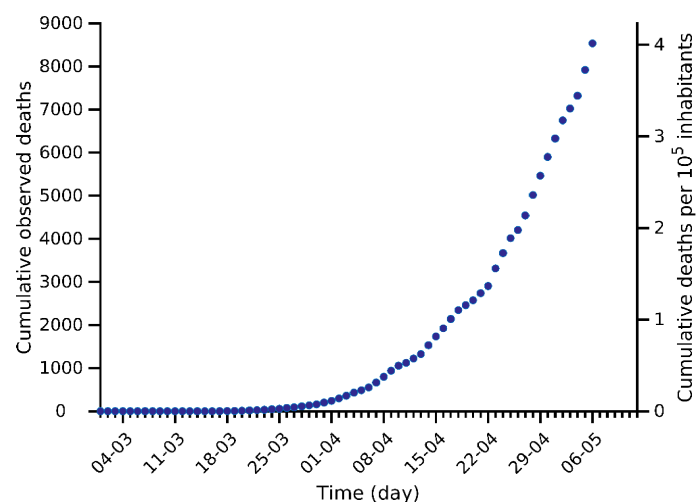
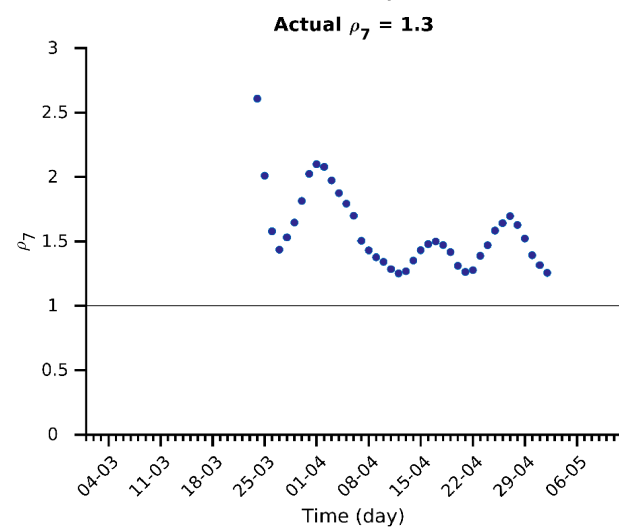
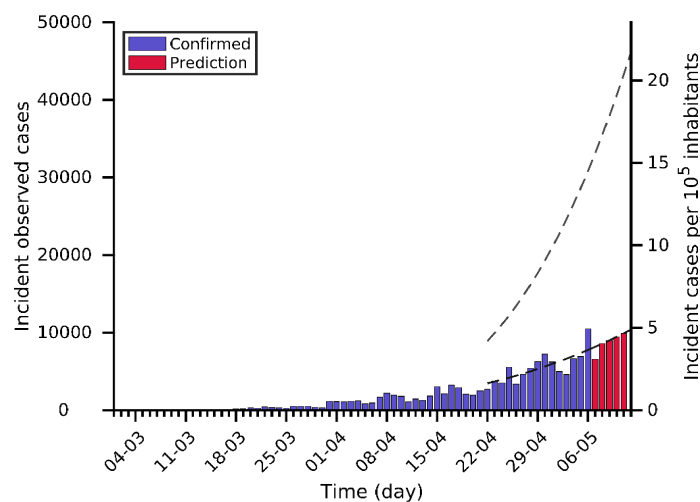
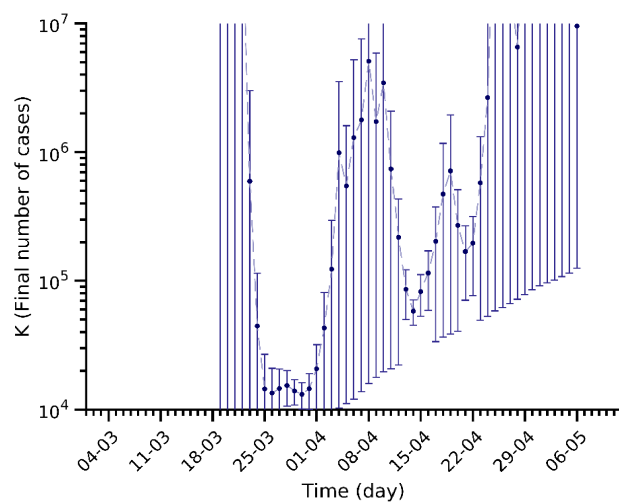
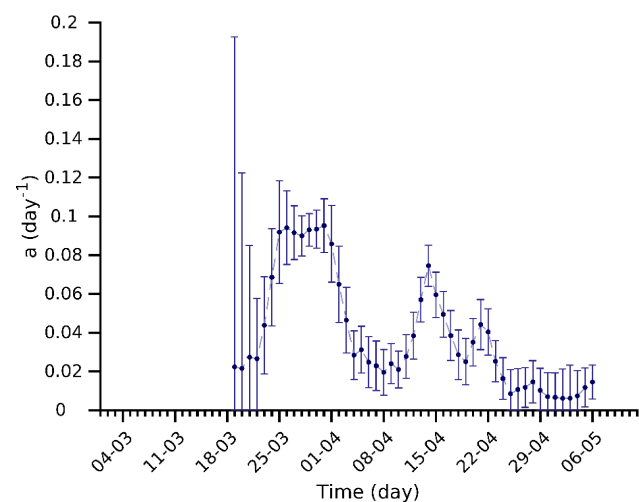
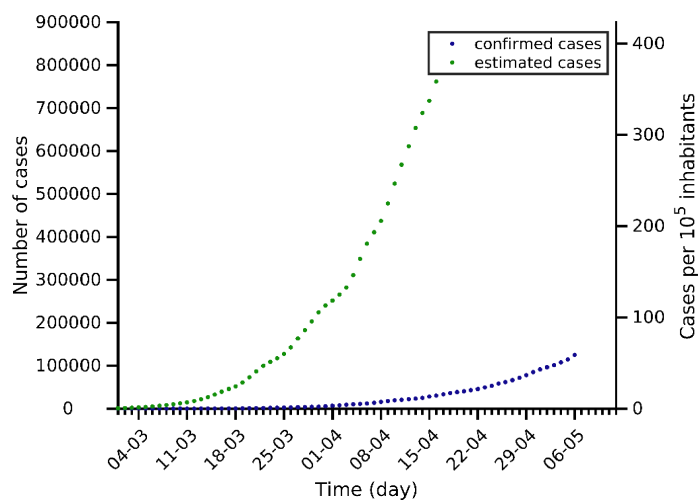
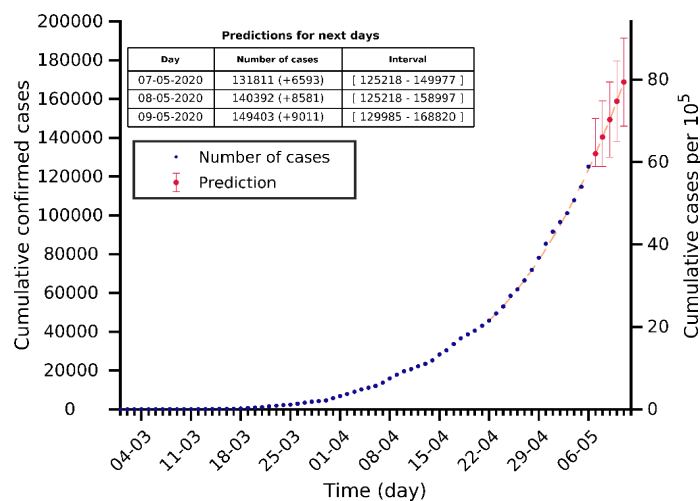
Russia 06-05-2020. Population: 145.9M. Current cumulated incidence: 114/10⁵



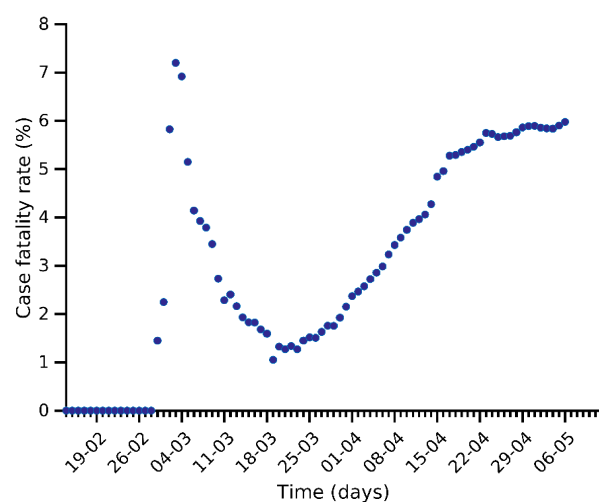
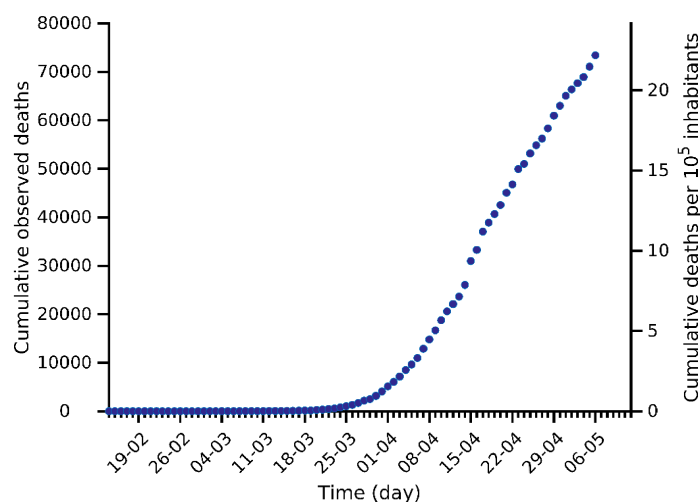
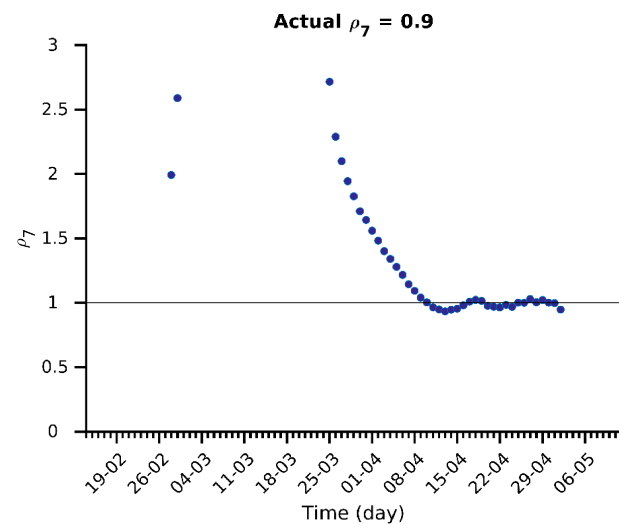
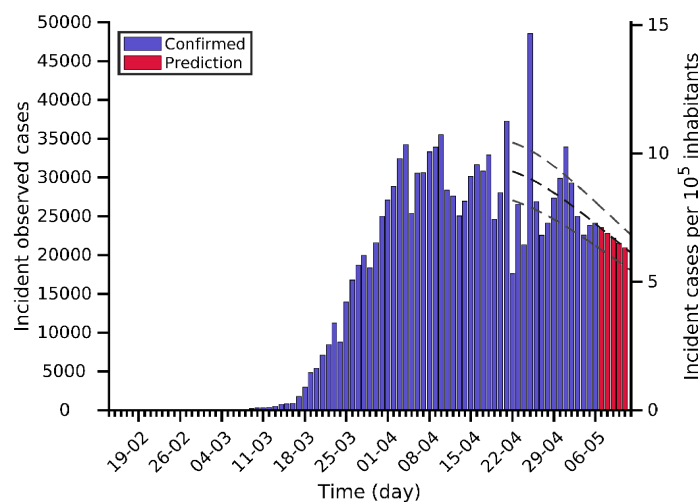
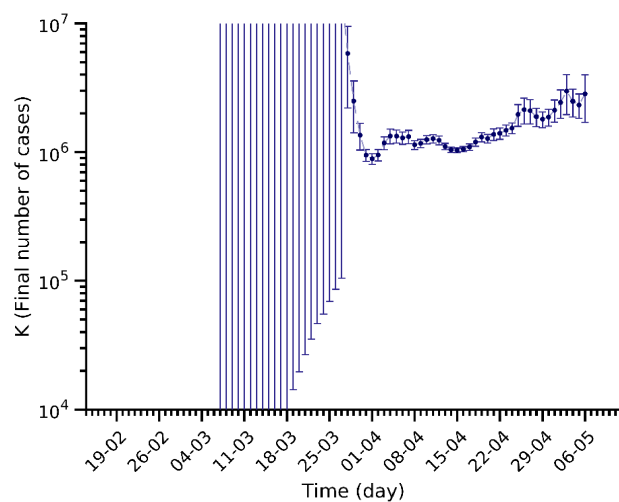
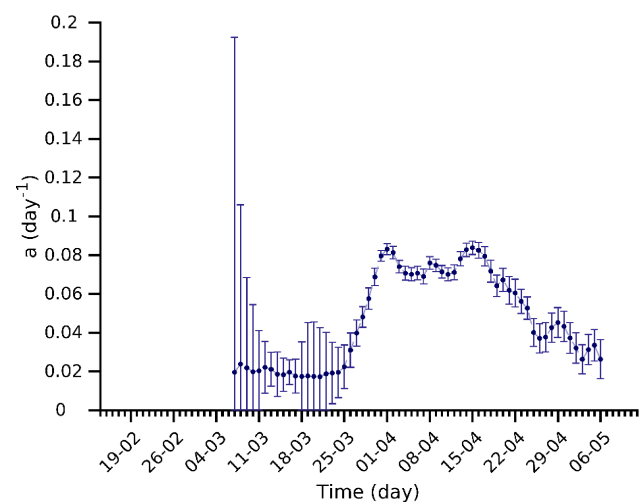
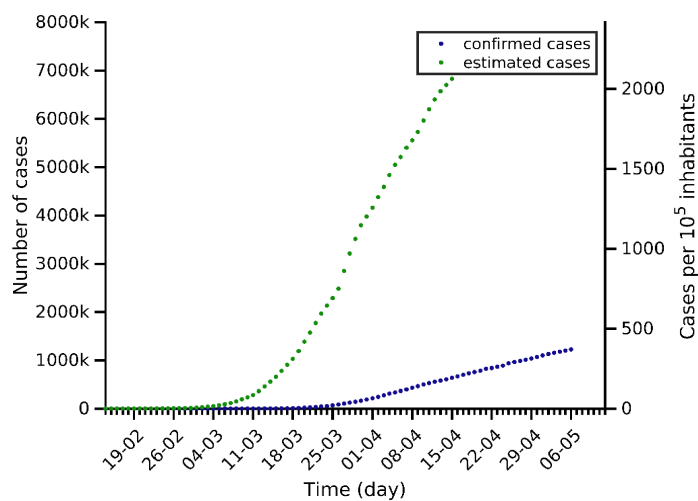
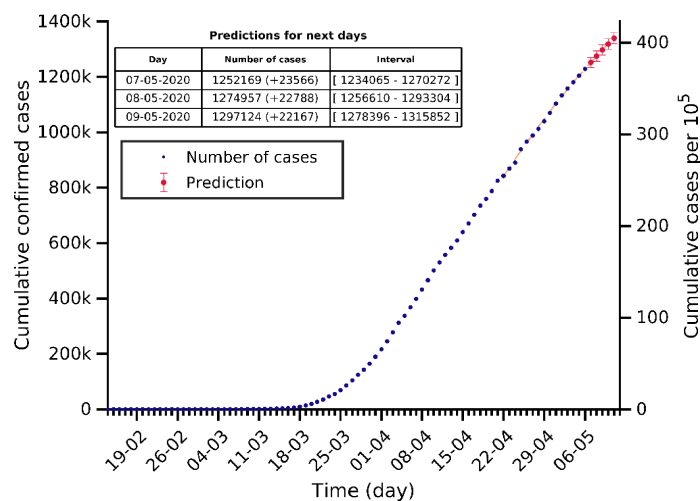
Turkey 06-05-2020. Population: 84.3M. Current cumulated incidence: 156/10⁵



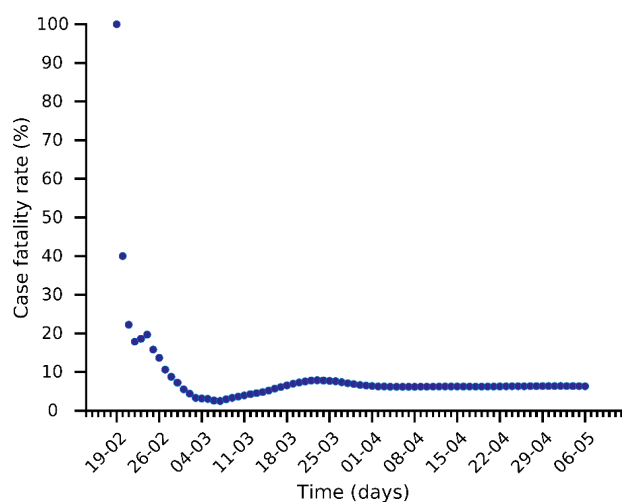
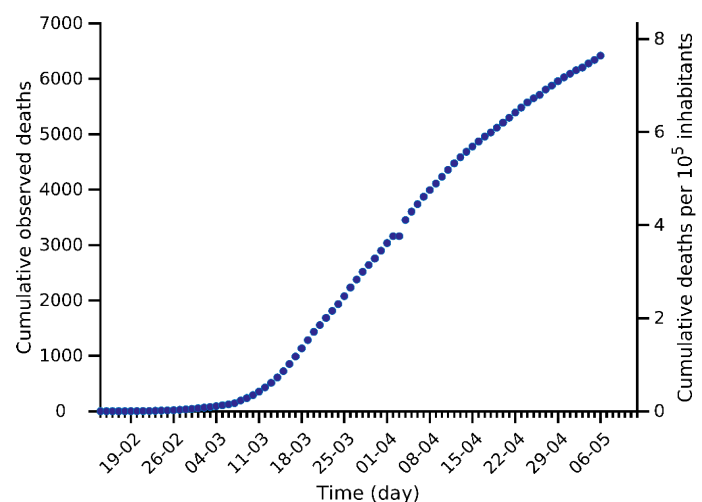
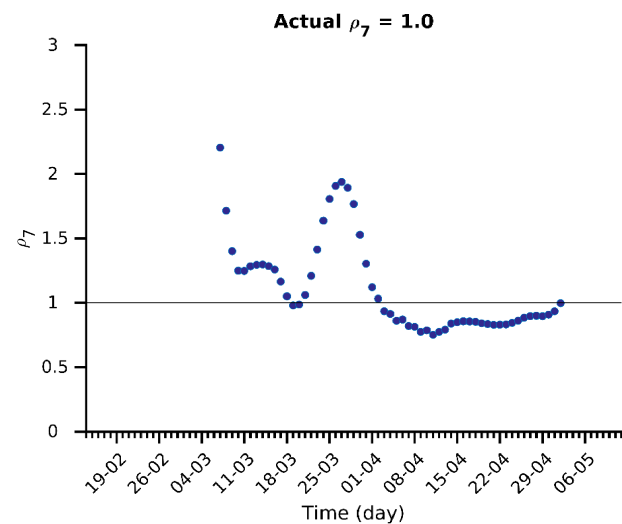
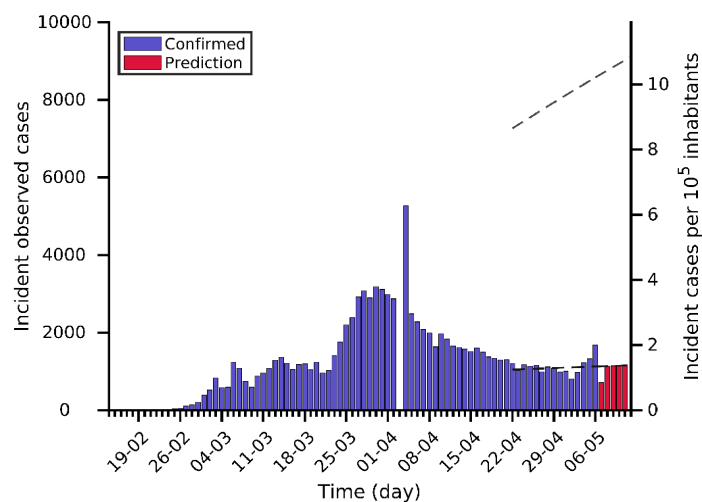
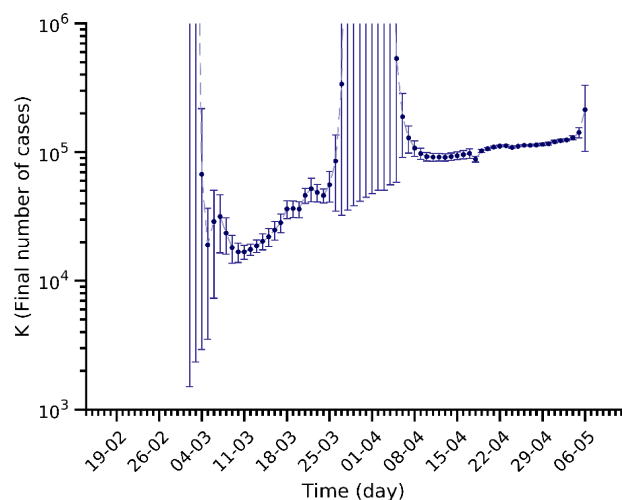
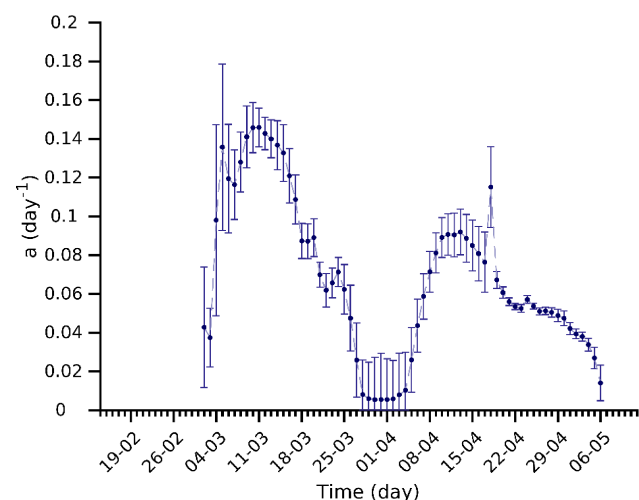
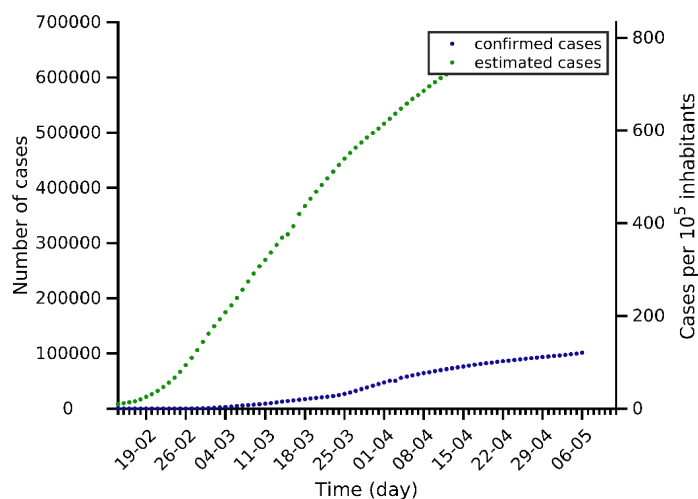
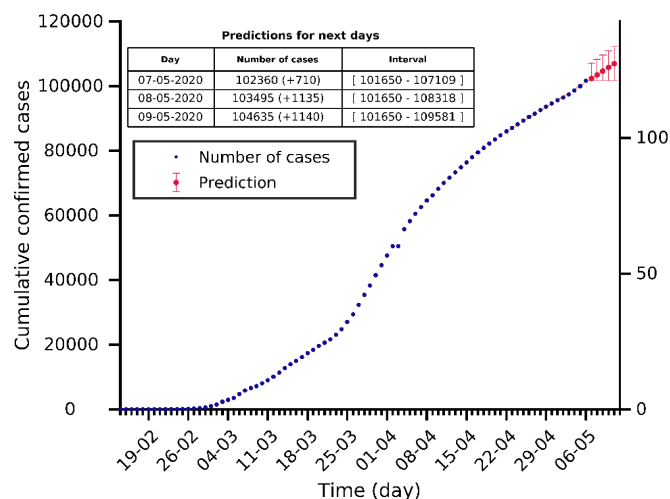
Brazil 06-05-2020. Population: 212.6M. Current cumulated incidence: 59/10⁵



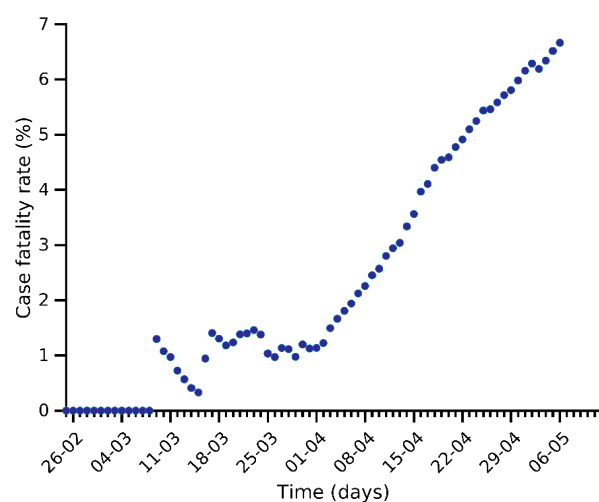
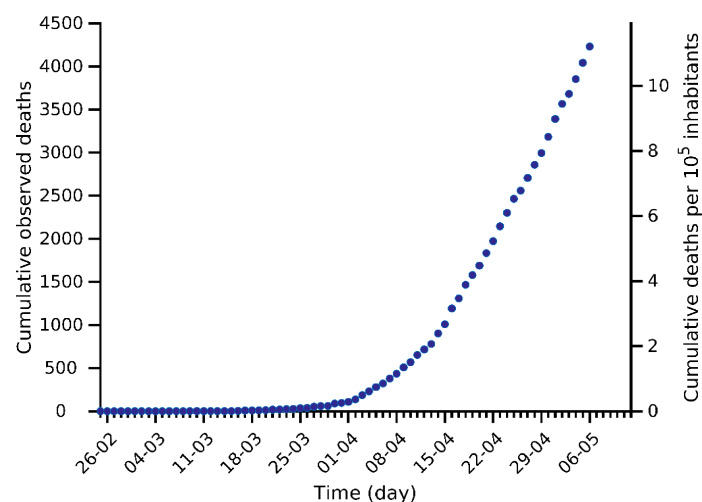
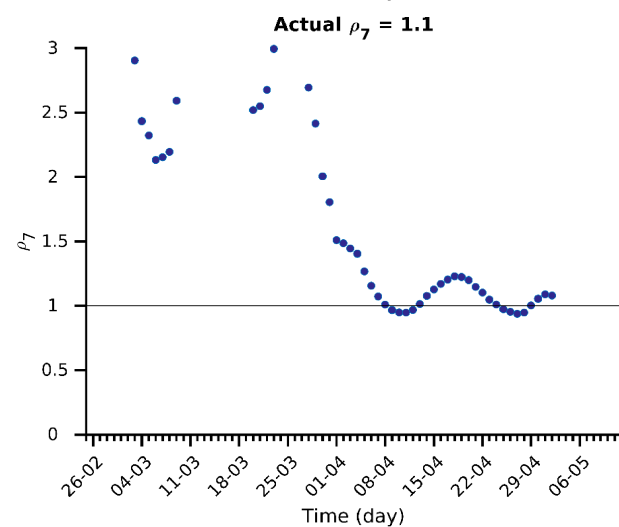
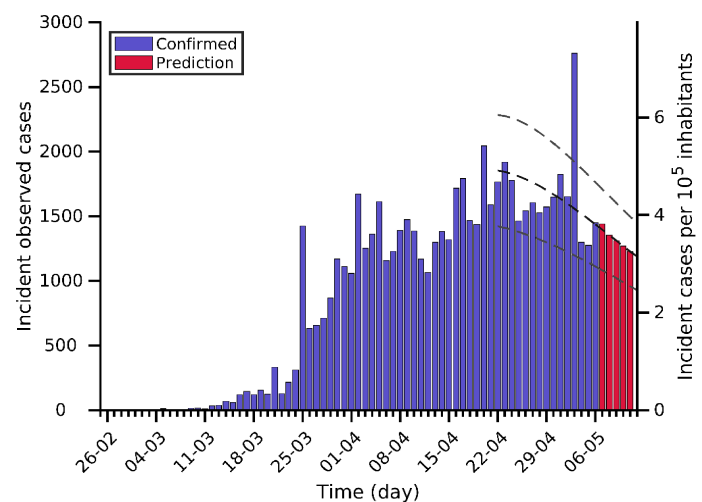
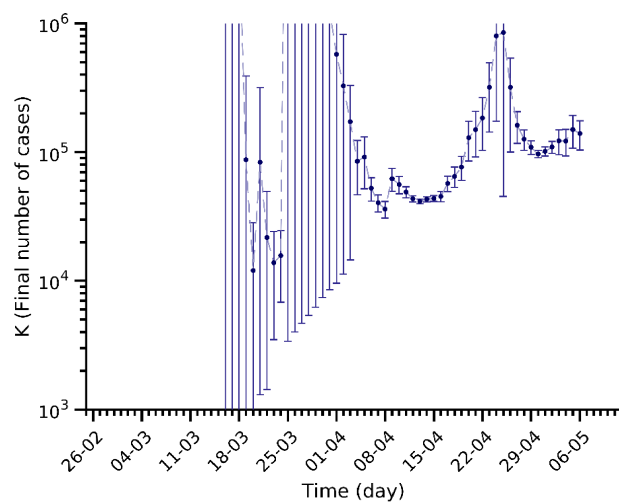
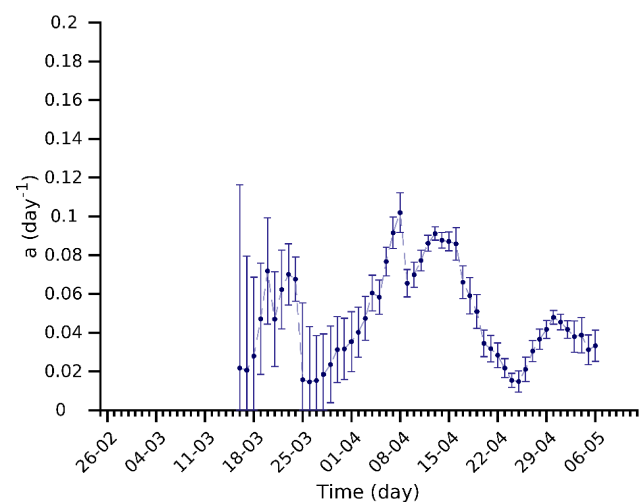
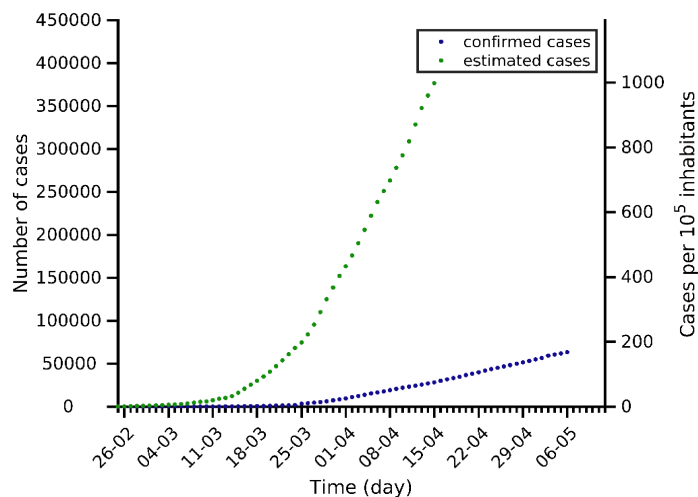
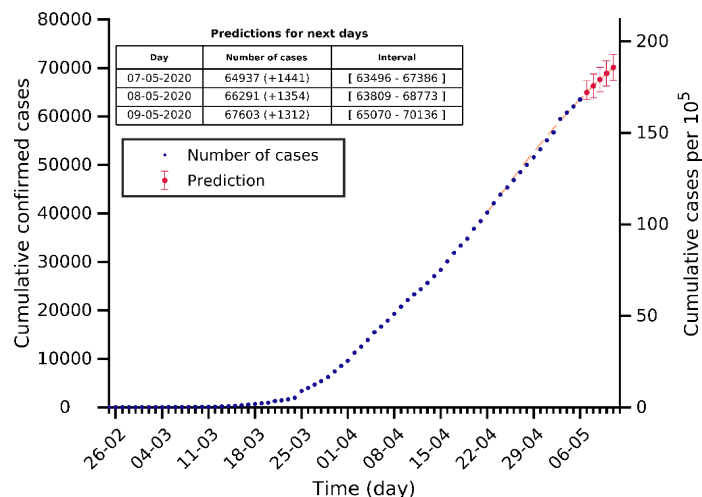
USA 06-05-2020. Population: 331.0M. Current cumulated incidence: 371/10⁵



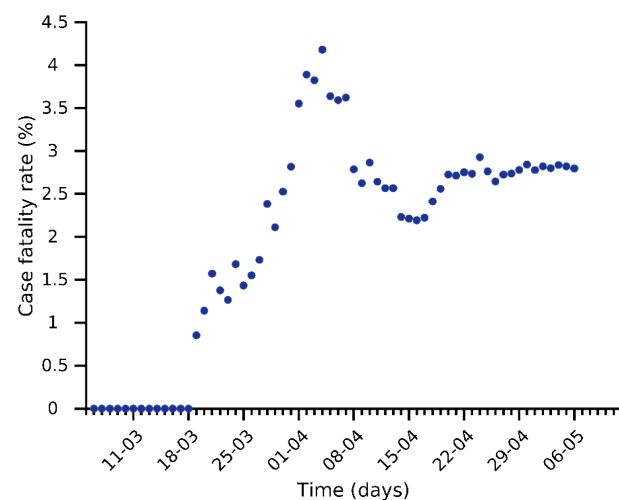
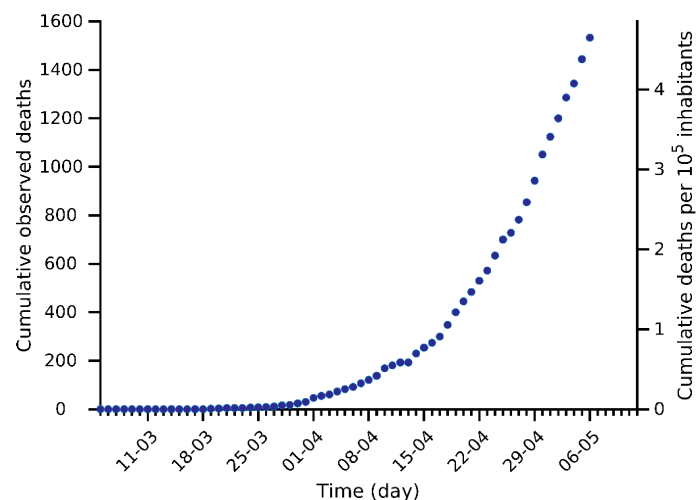
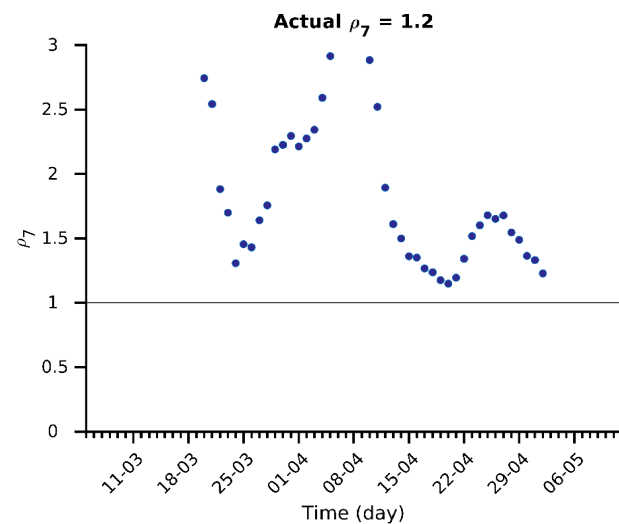
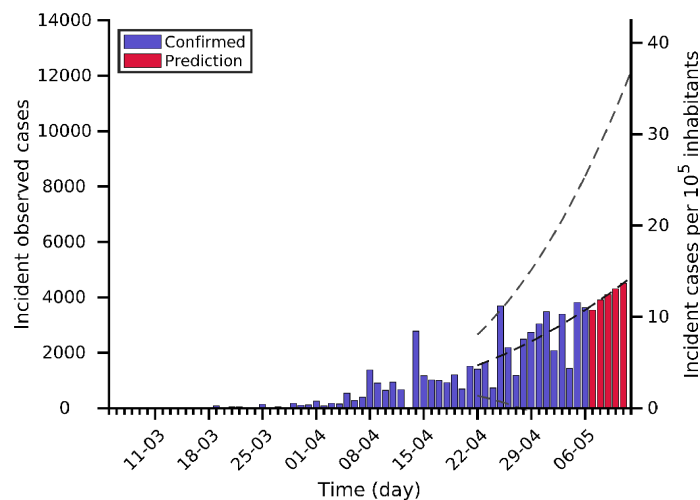
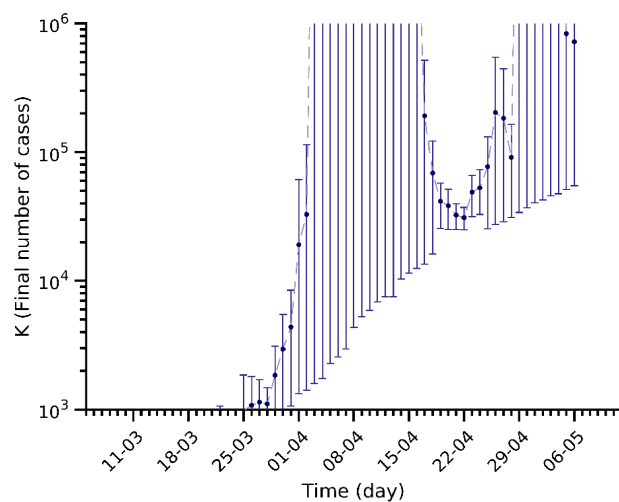
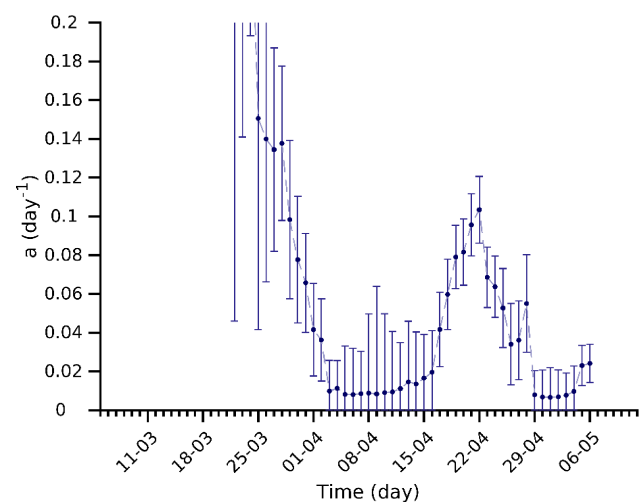
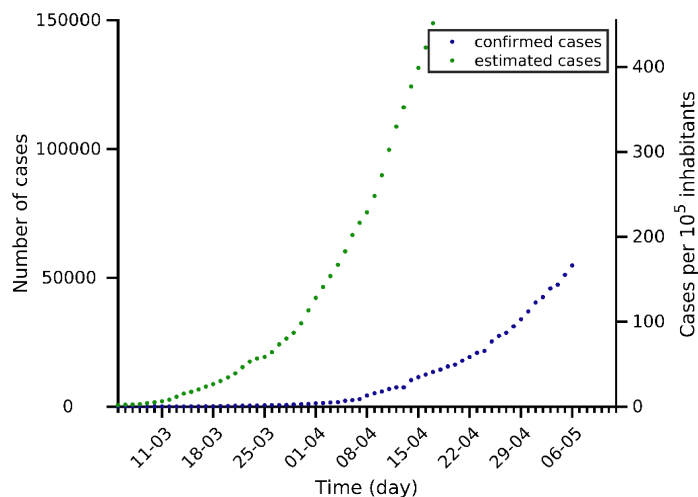
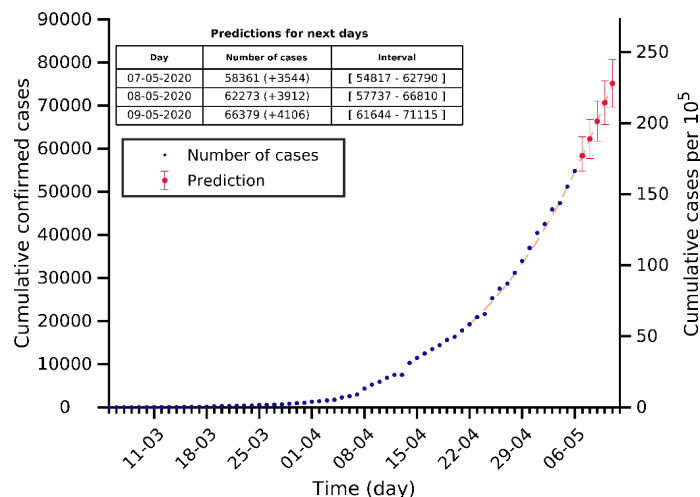
Iran 06-05-2020. Population: 84.0M. Current cumulated incidence: 121/10⁵



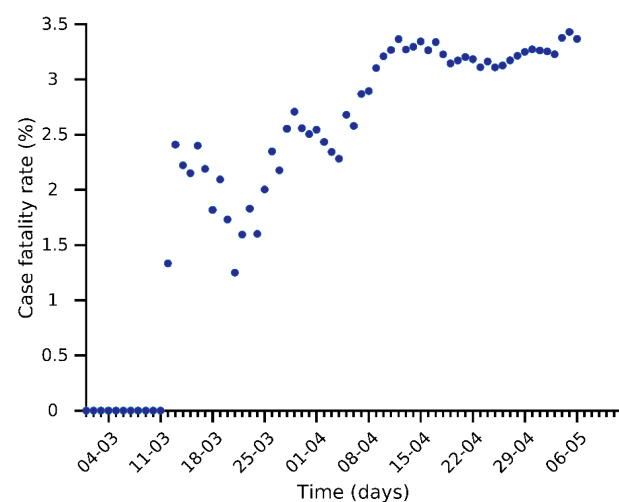
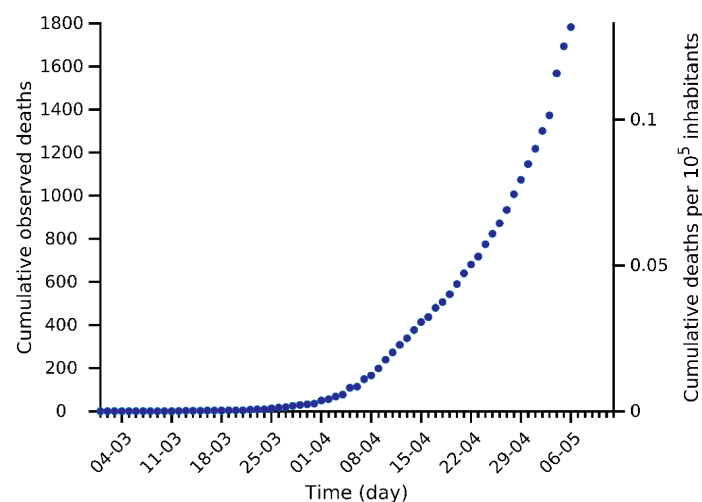
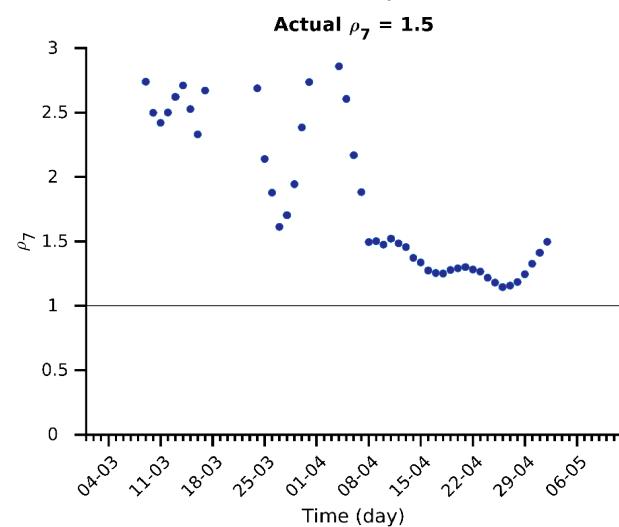
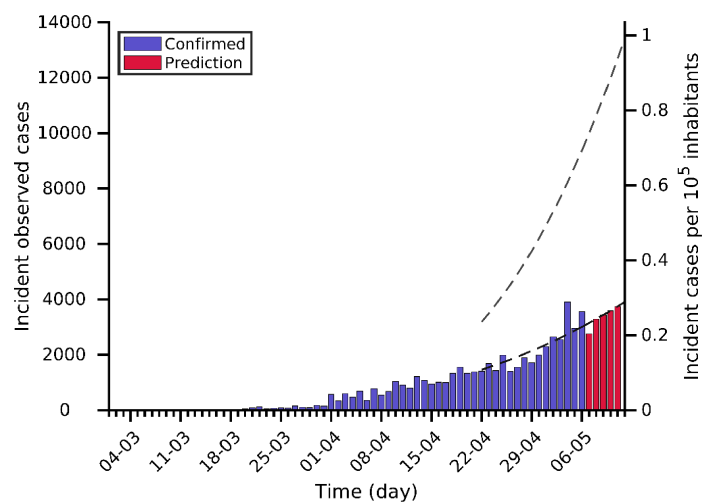
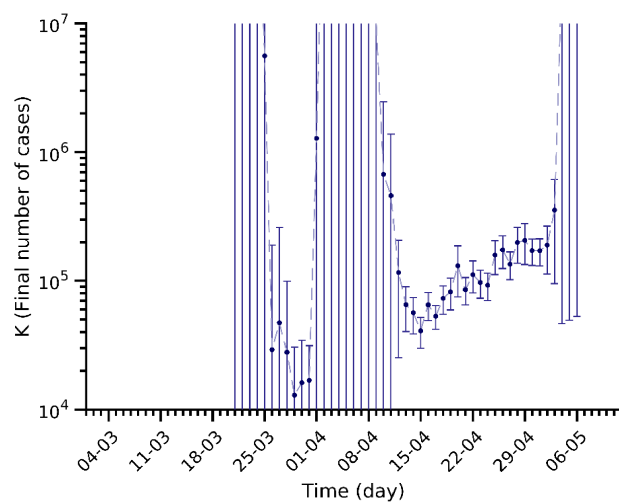
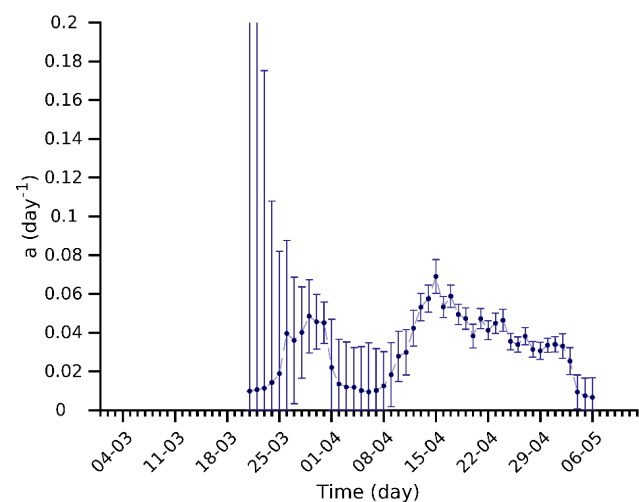
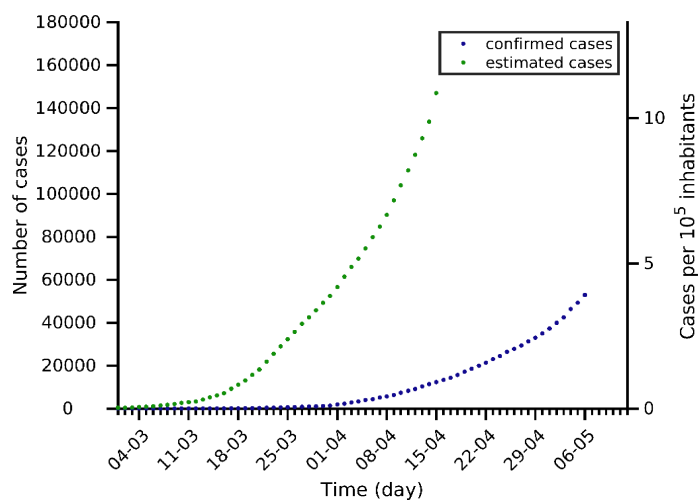
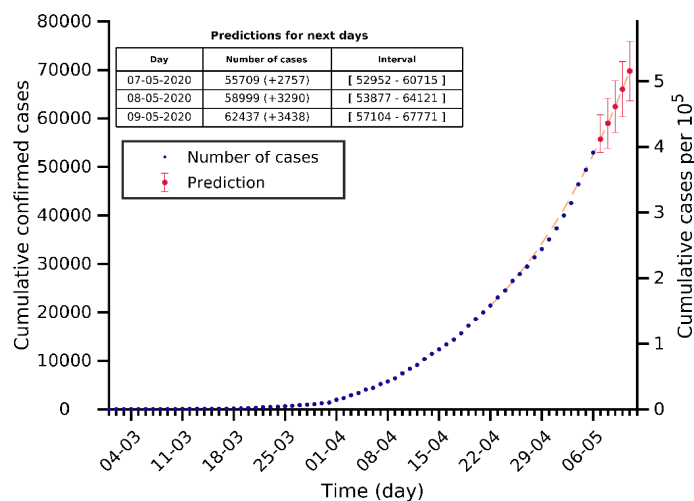
Canada 06-05-2020. Population: 37.7M. Current cumulated incidence: 168/10⁵



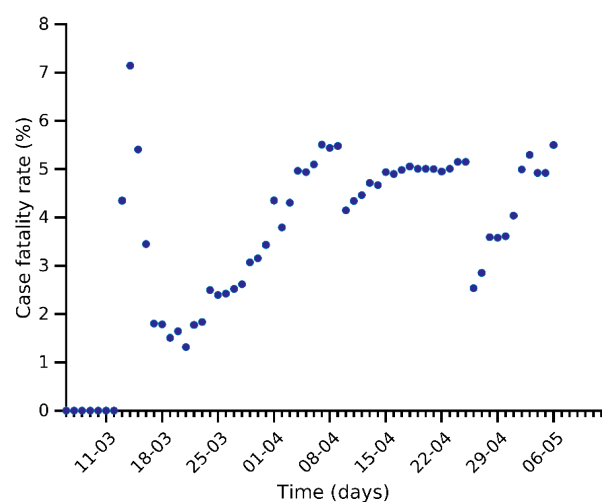
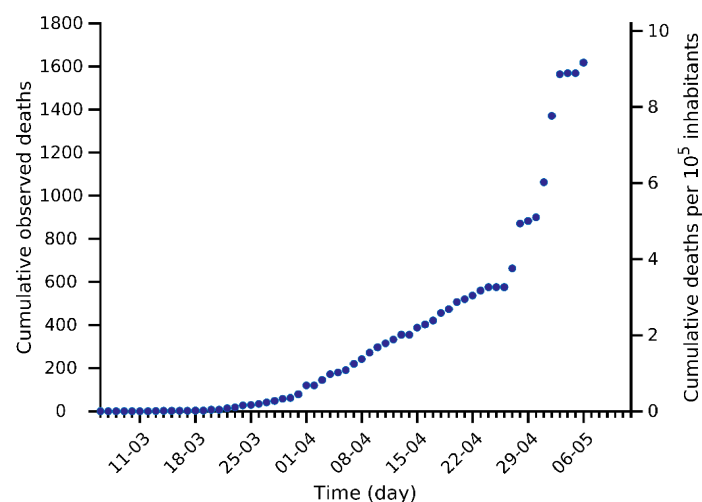
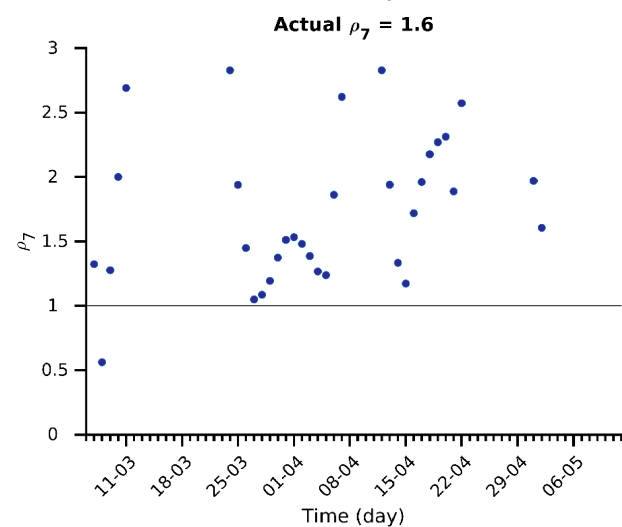
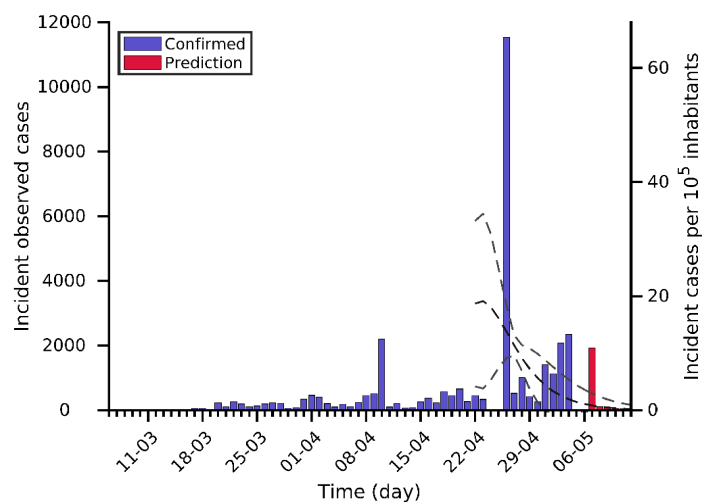
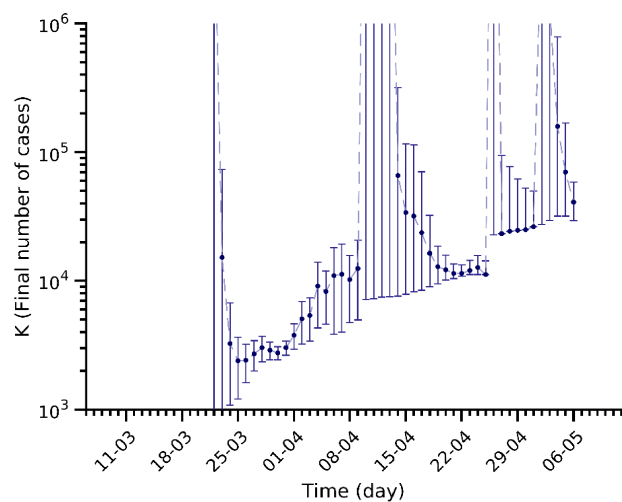
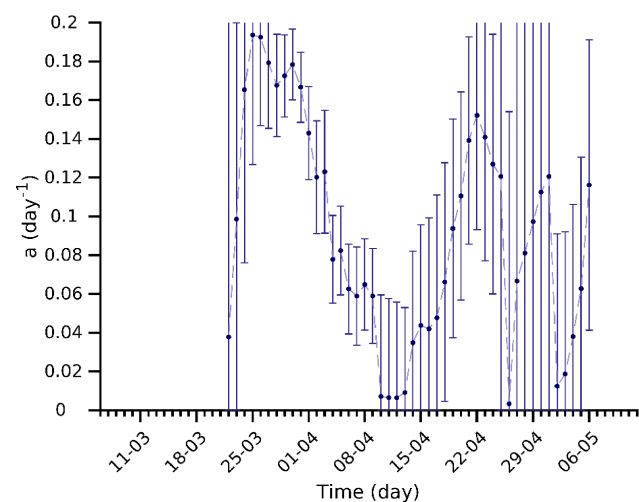
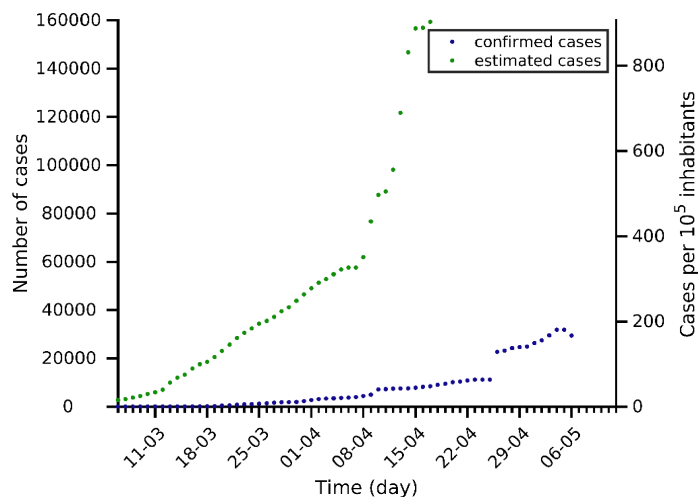
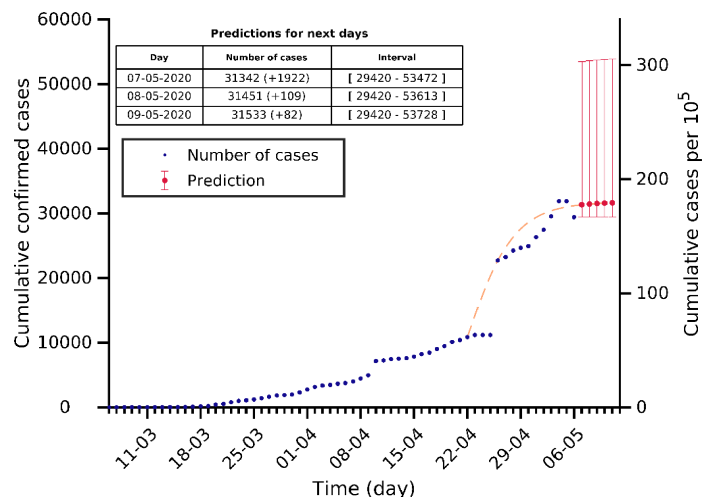
Peru 06-05-2020. Population: 33.0M. Current cumulated incidence: 166/10⁵



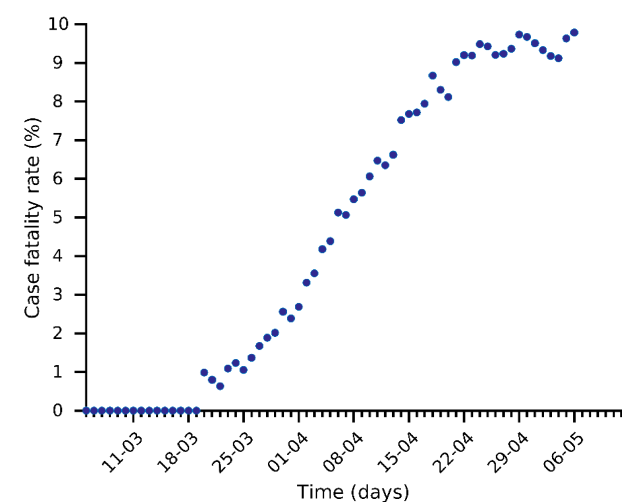
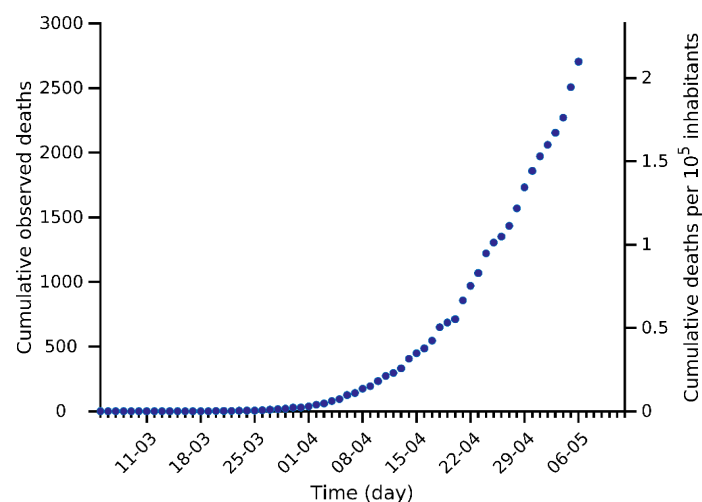
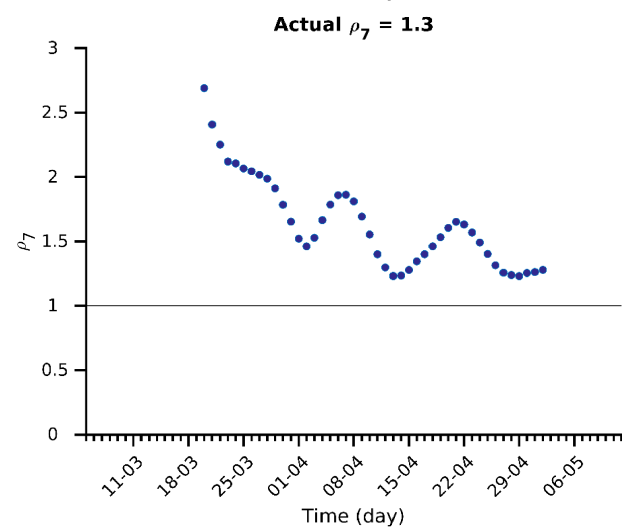
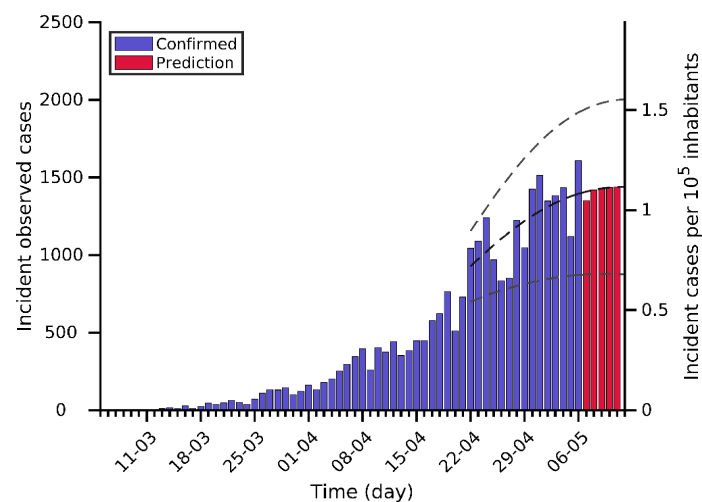
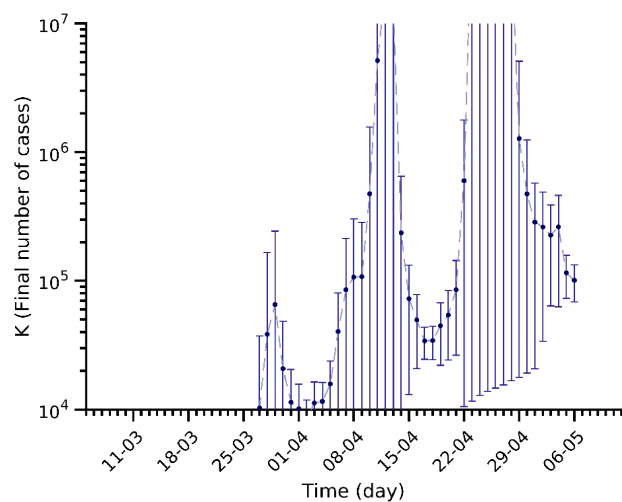
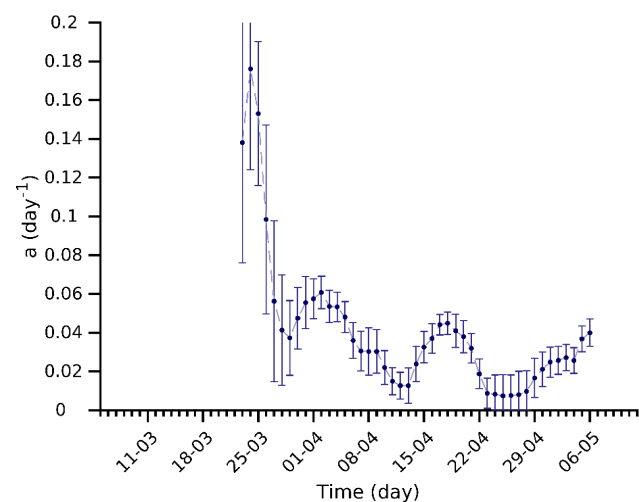
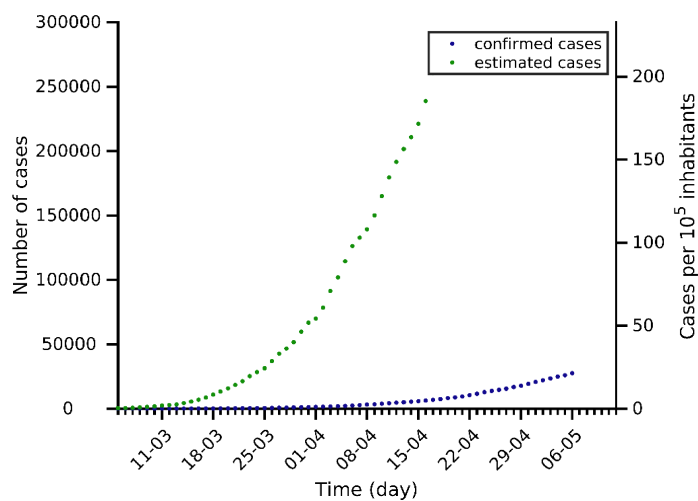
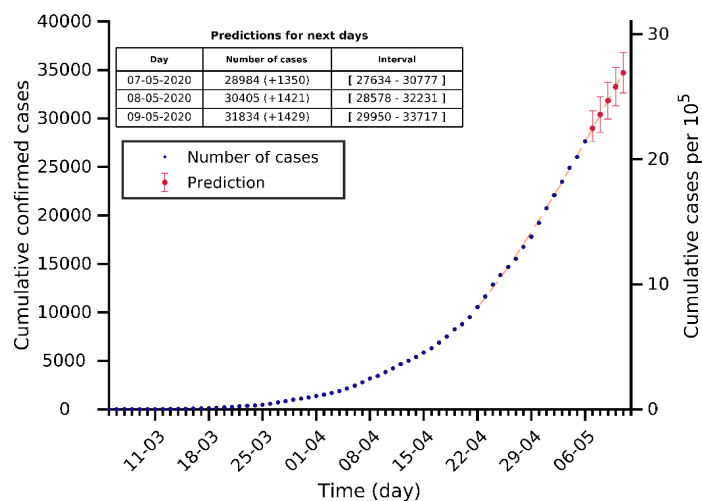
India 06-05-2020. Population: 1353.0M. Current cumulated incidence: 4/10⁵



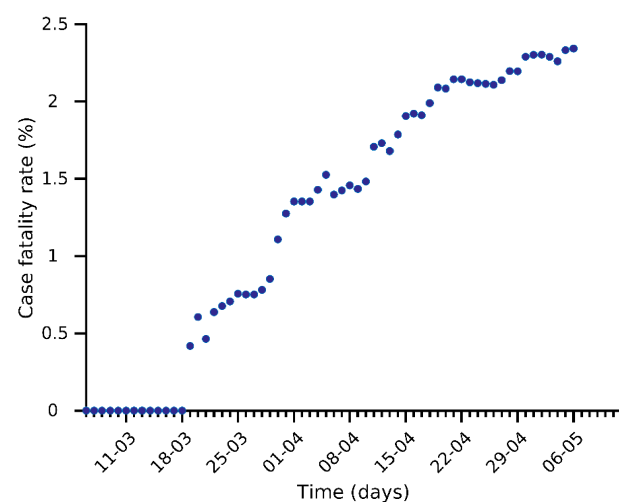
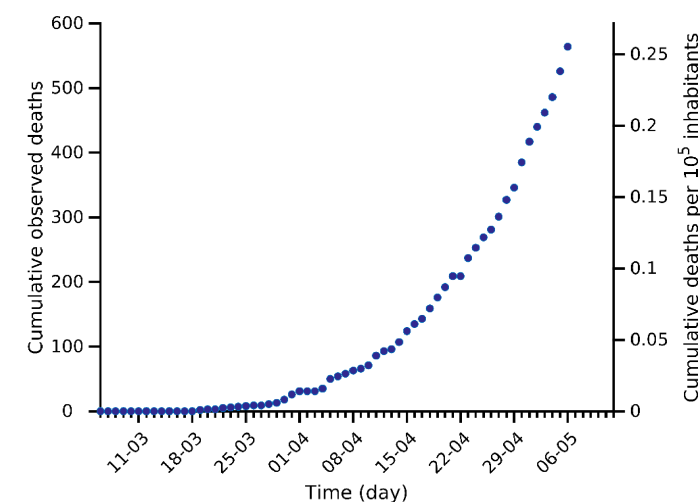
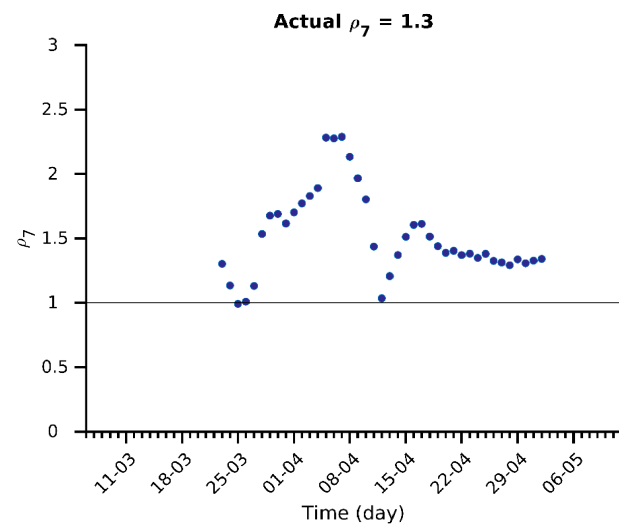
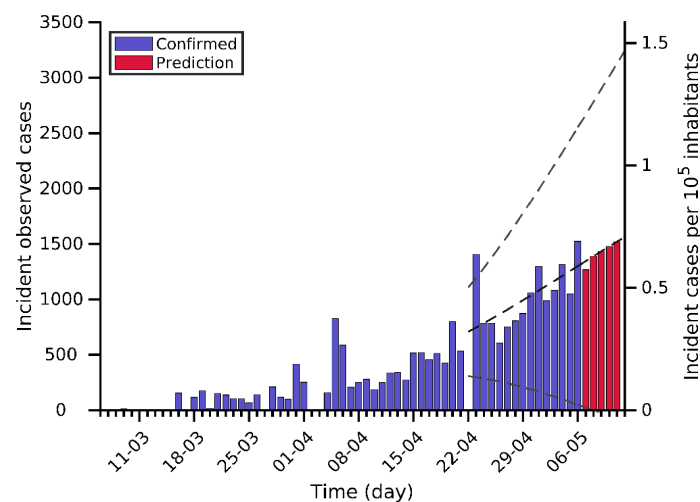
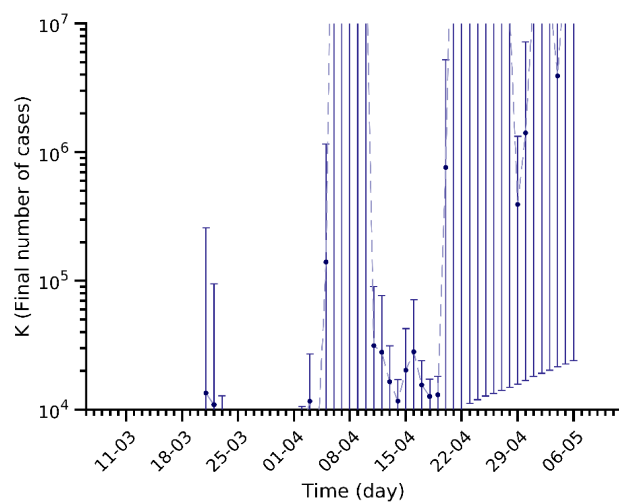
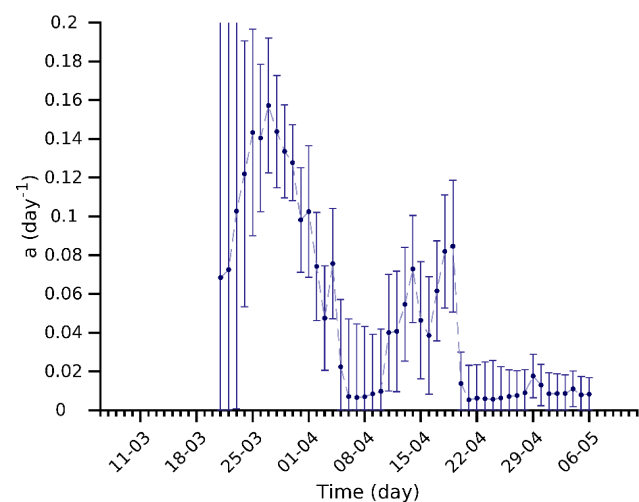
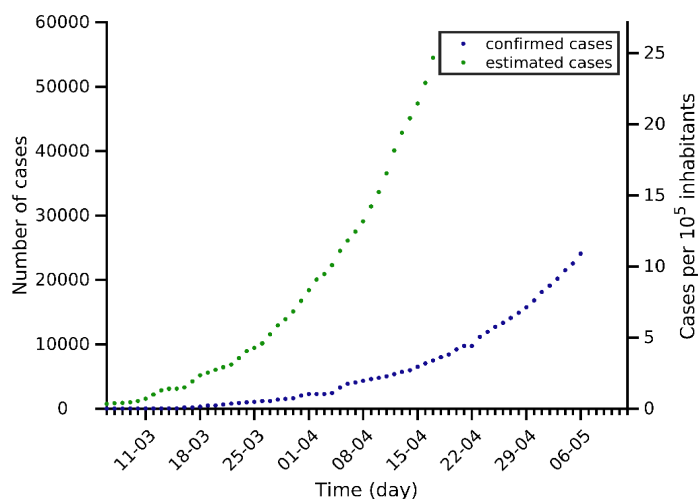
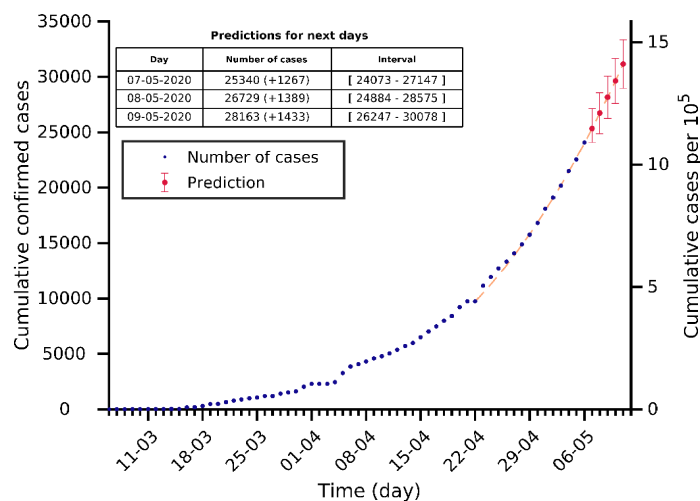
Ecuador 06-05-2020. Population: 17.6M. Current cumulated incidence: 167/10⁵



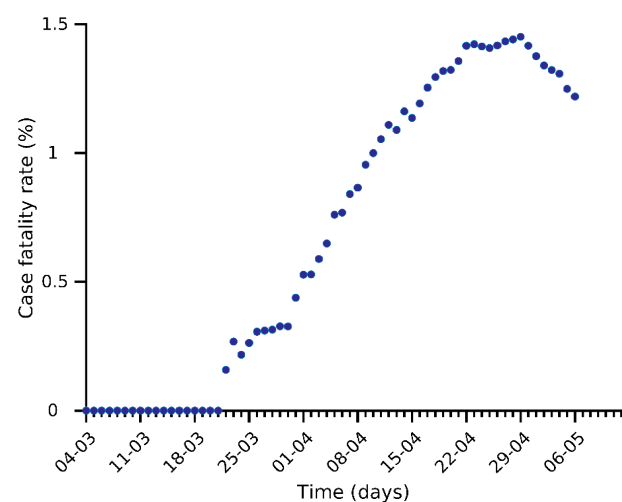
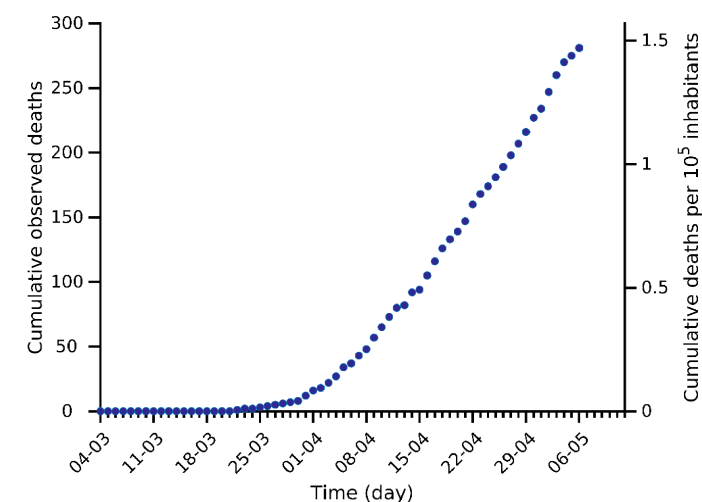
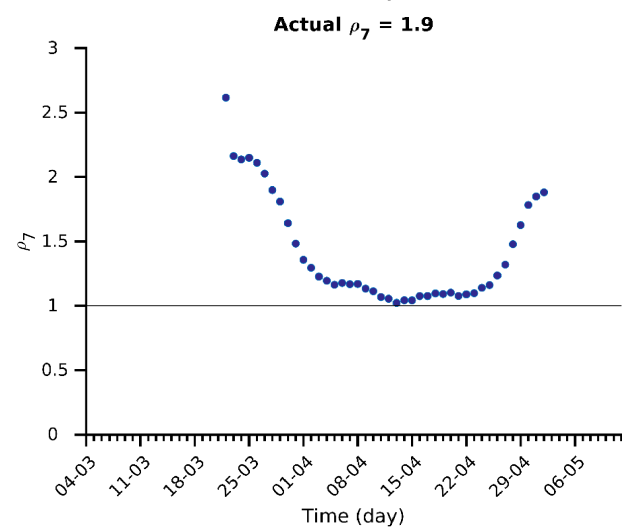
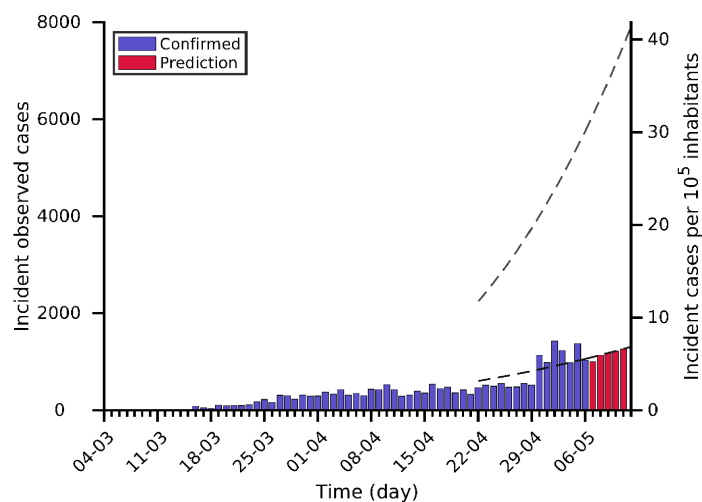
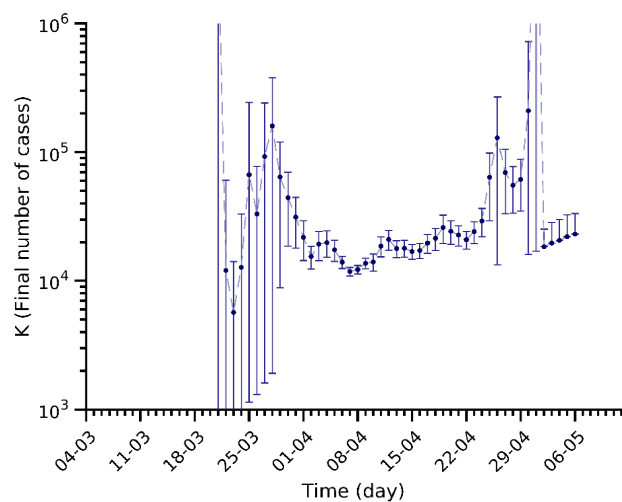
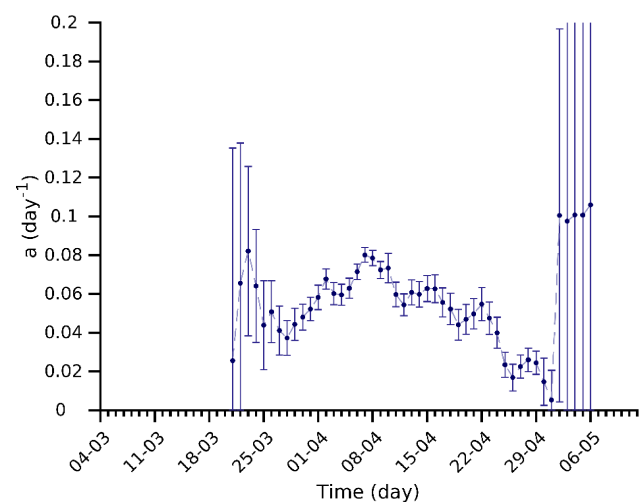
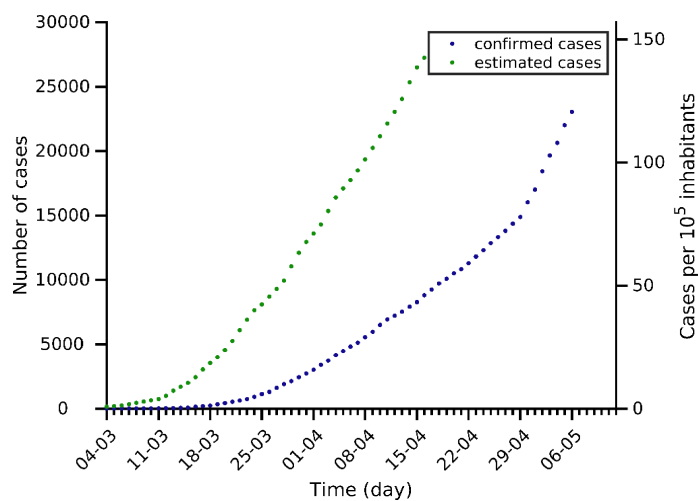
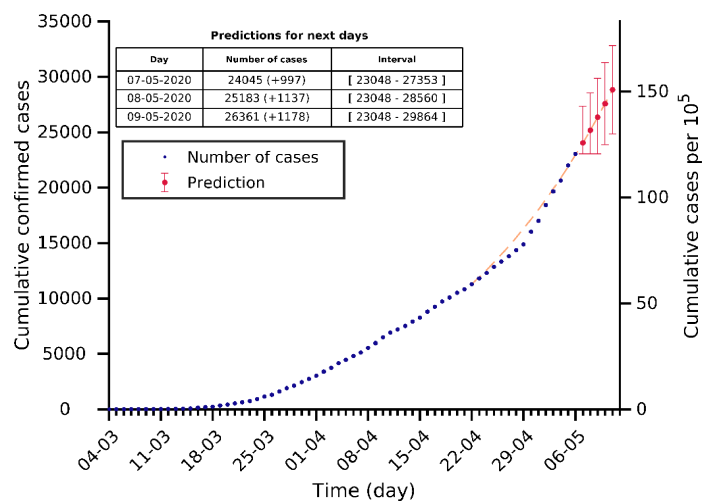
Mexico 06-05-2020. Population: 128.9M. Current cumulated incidence: 21/10⁵



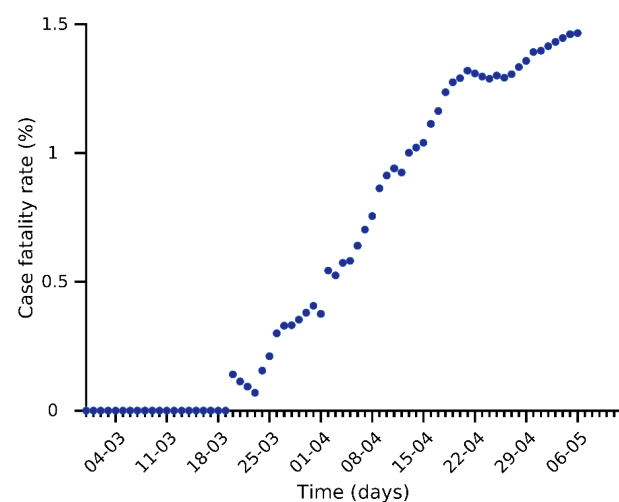
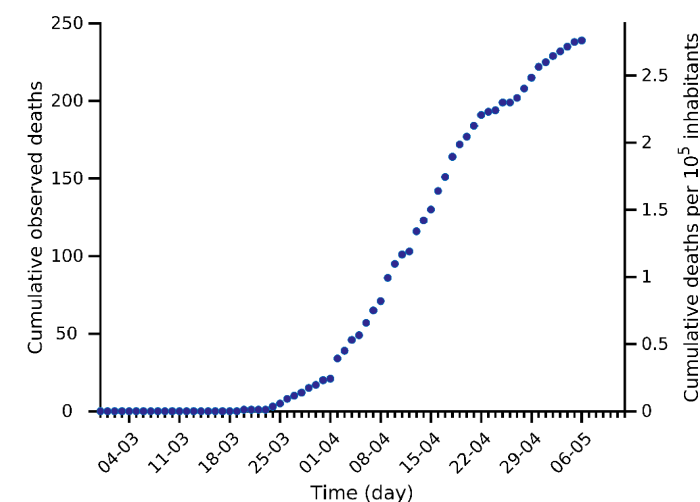
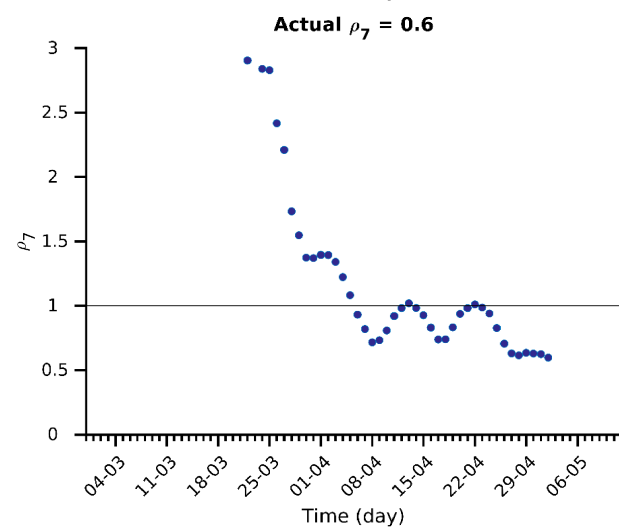
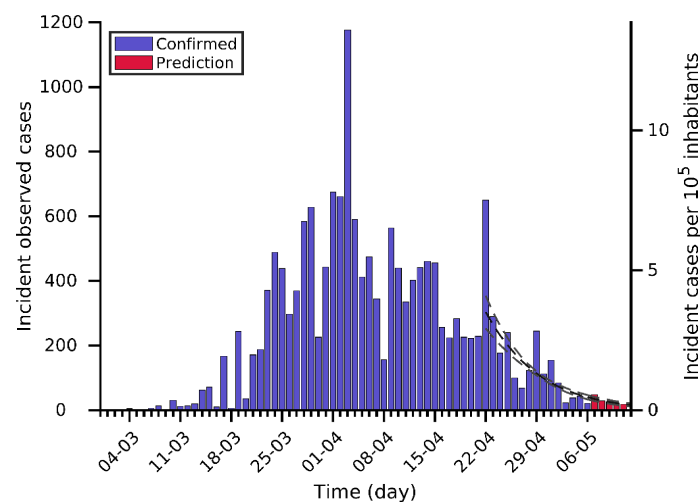
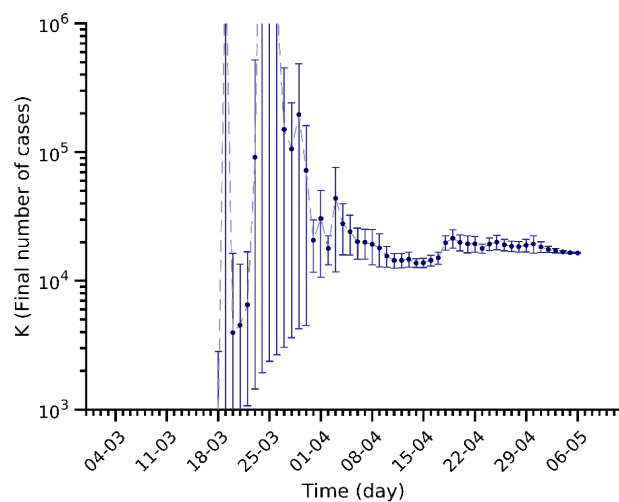
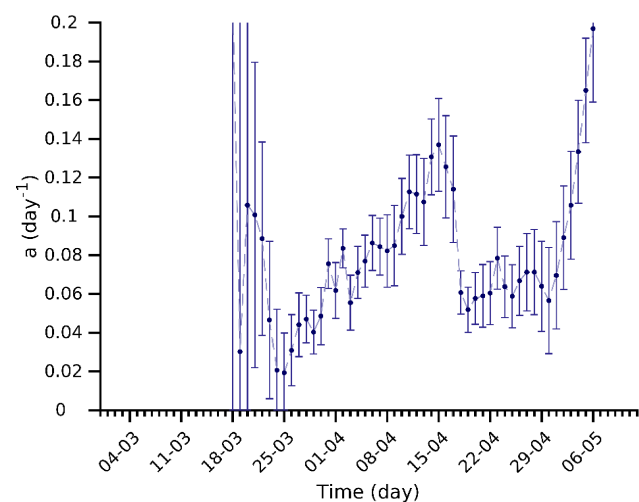
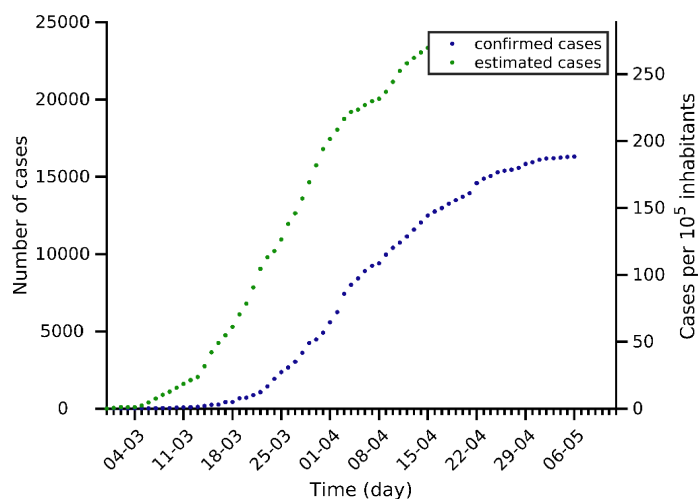
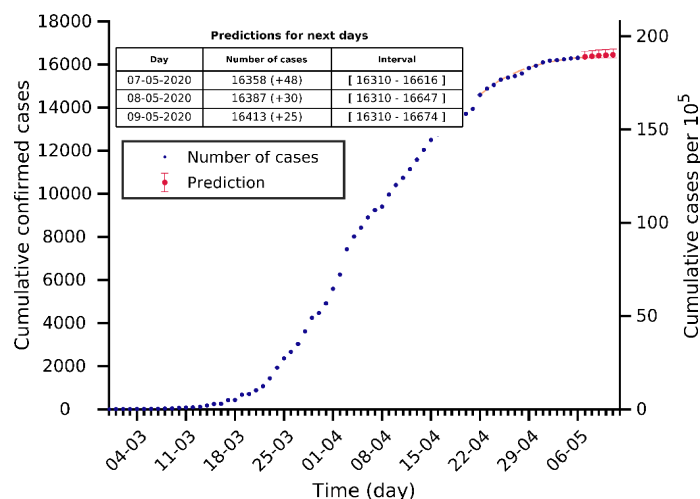
Pakistan 06-05-2020. Population: 220.9M. Current cumulated incidence: 11/10⁵



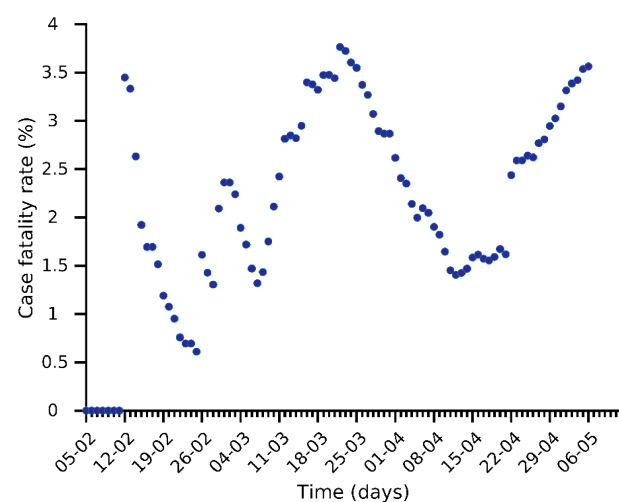
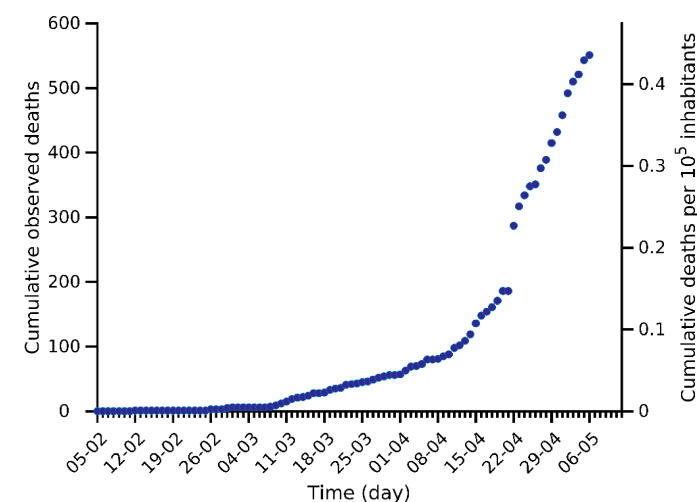
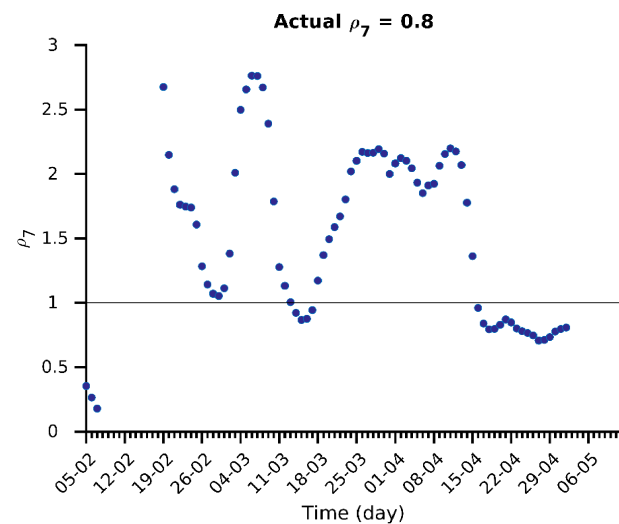
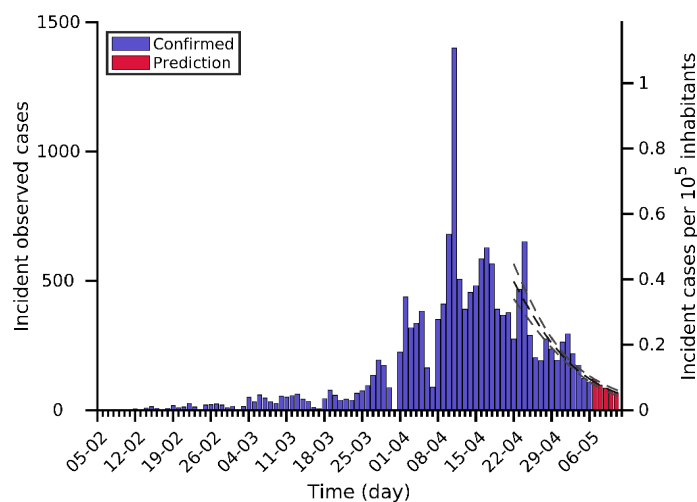
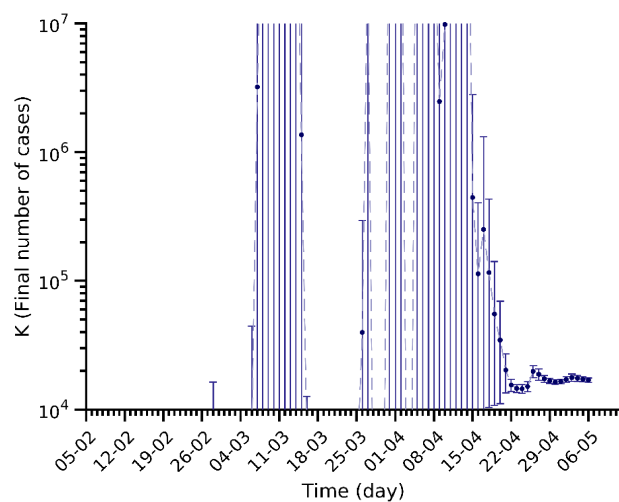
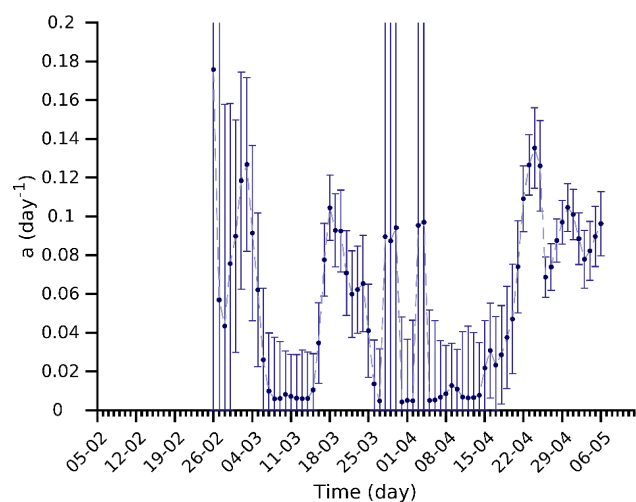
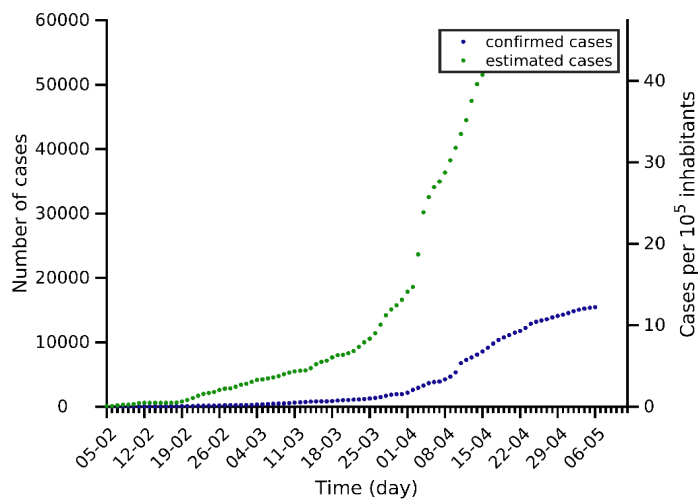
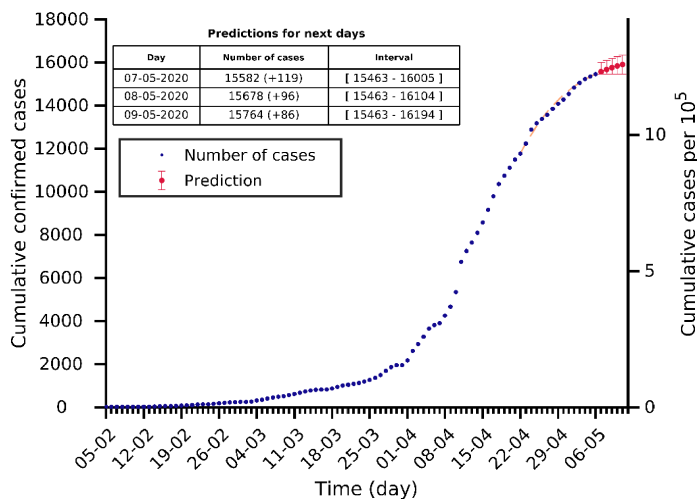
Chile 06-05-2020. Population: 19.1M. Current cumulated incidence: 121/10⁵



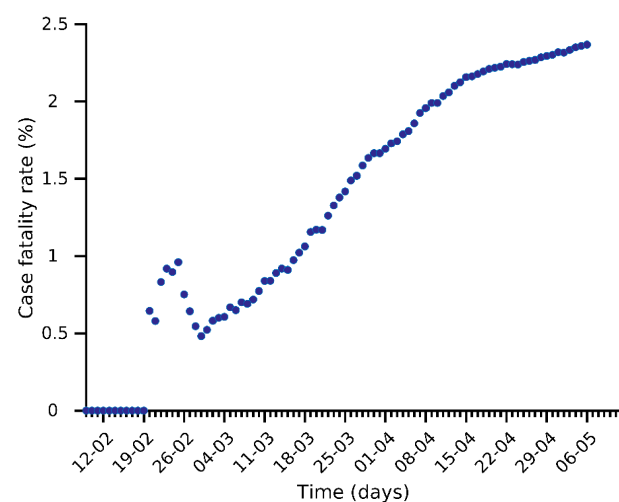
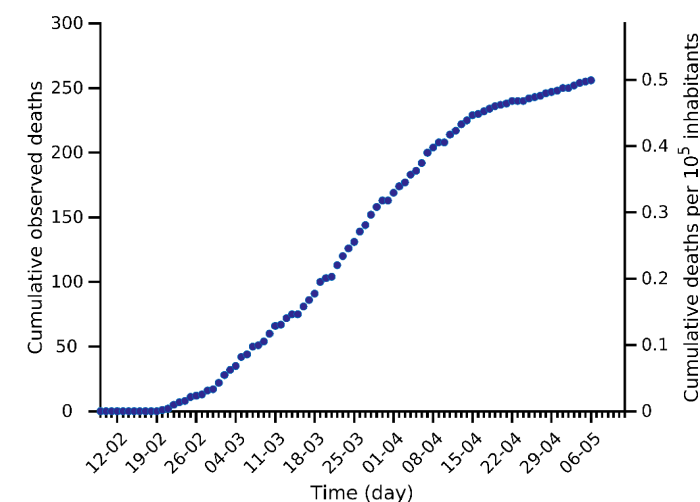
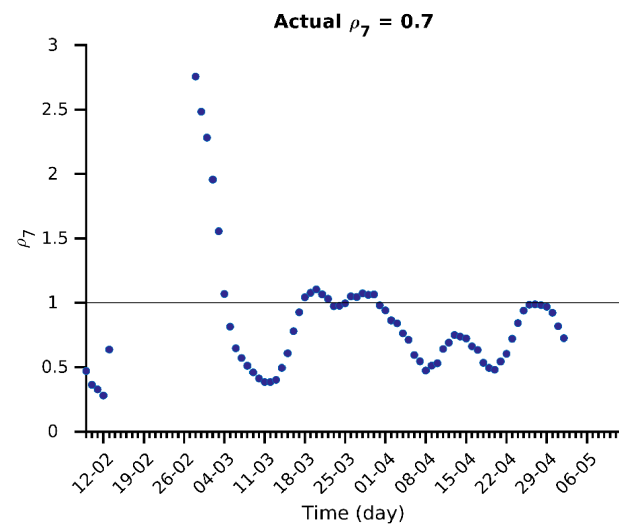
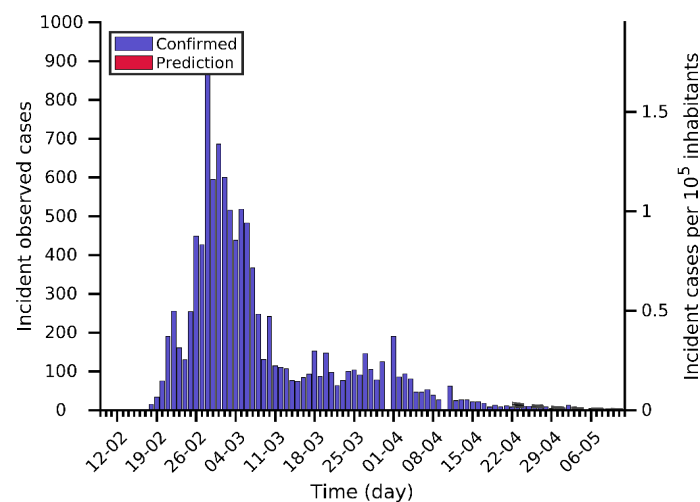
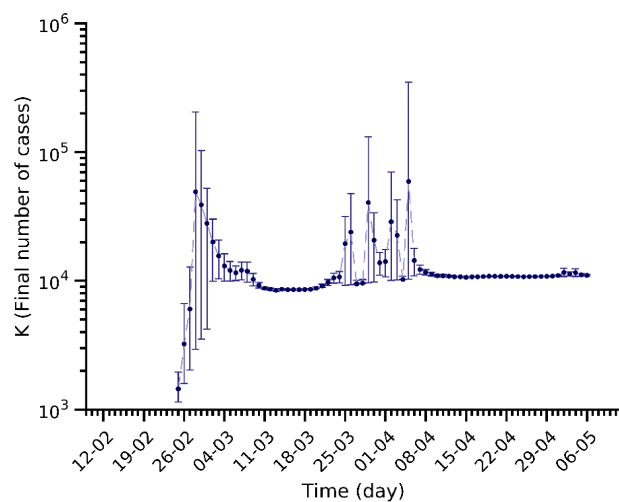
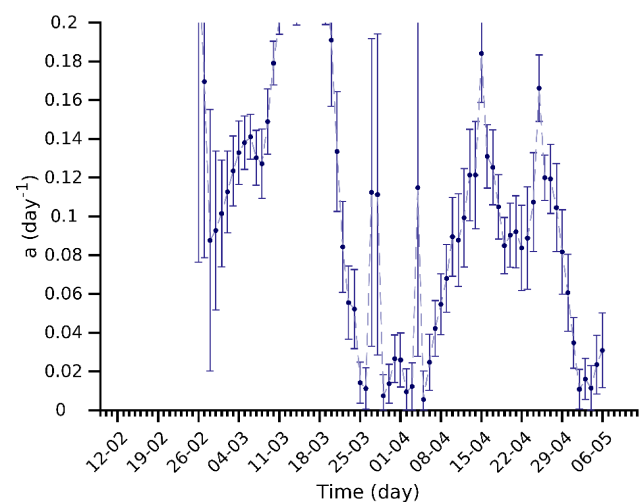
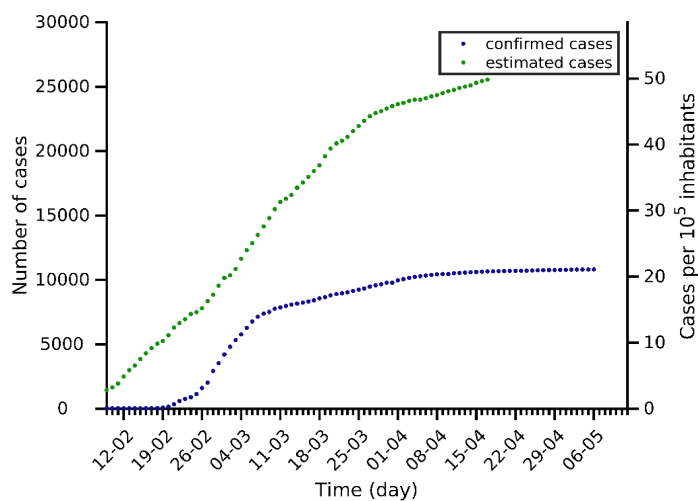
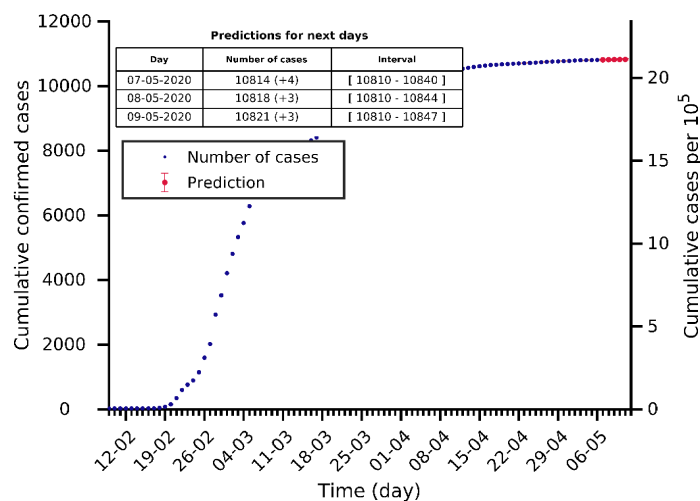
Israel 06-05-2020. Population: 8.7M. Current cumulated incidence: 188/10⁵



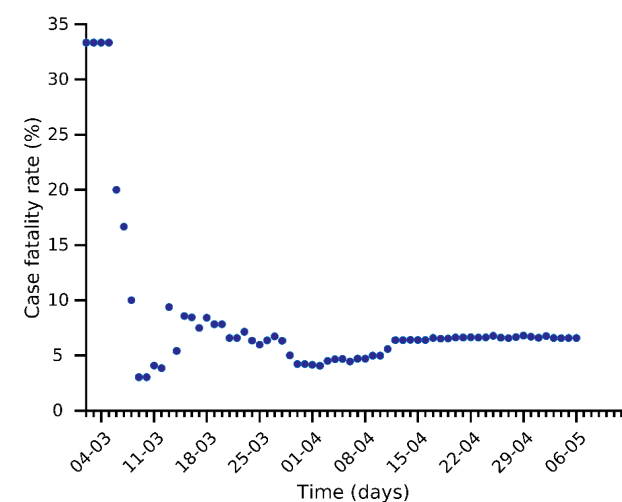
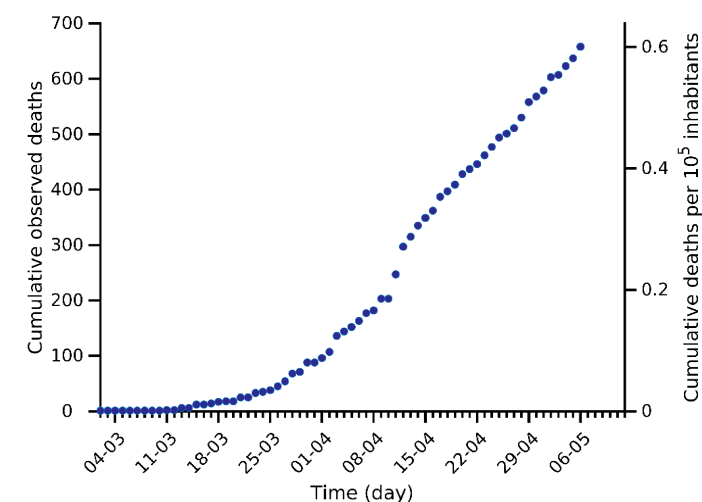
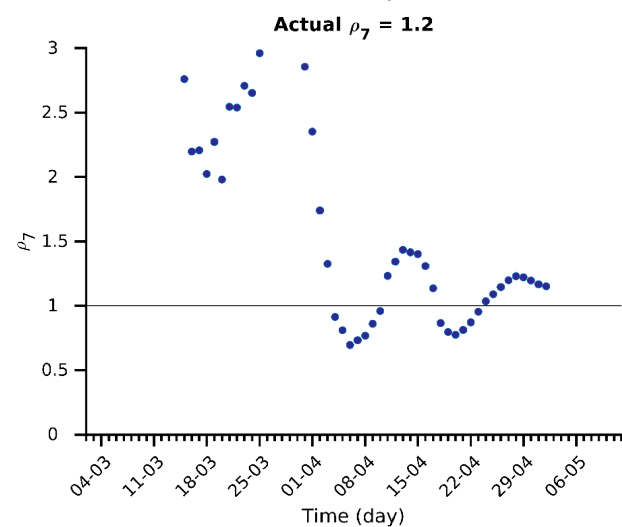
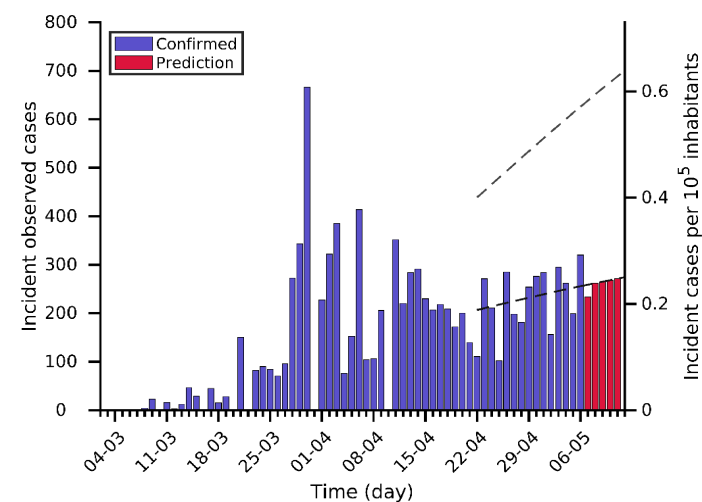
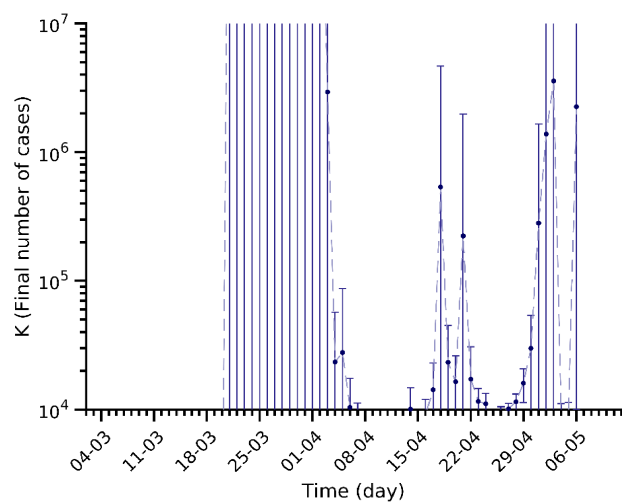
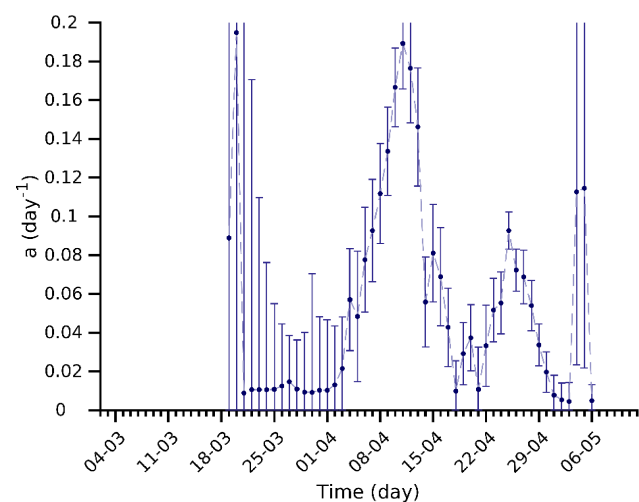
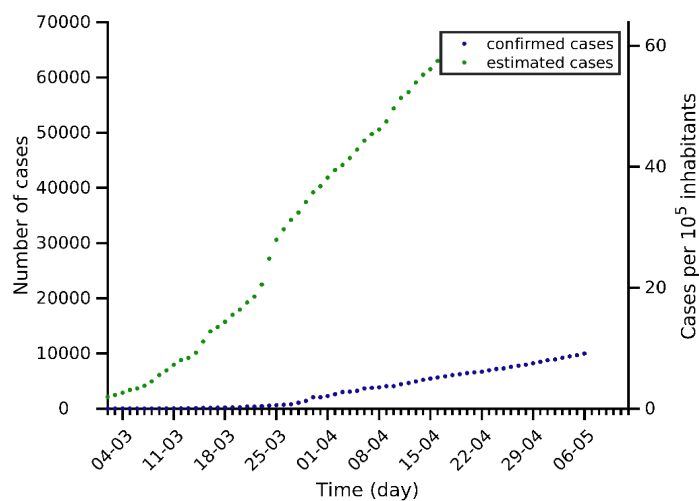
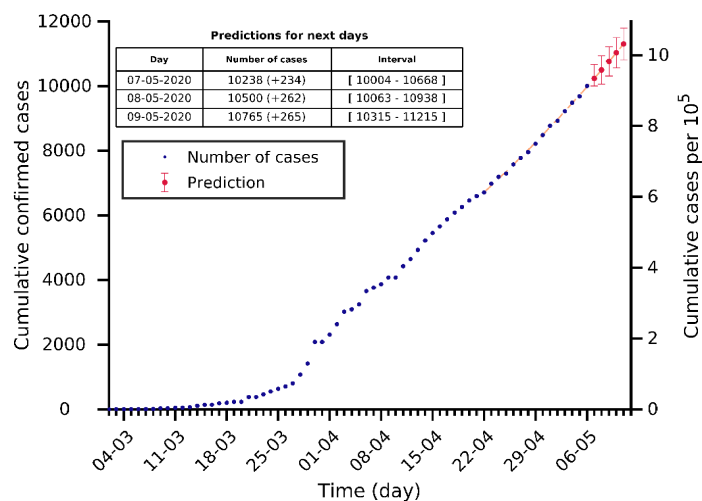
Japan 06-05-2020. Population: 126.5M. Current cumulated incidence: 12/10⁵



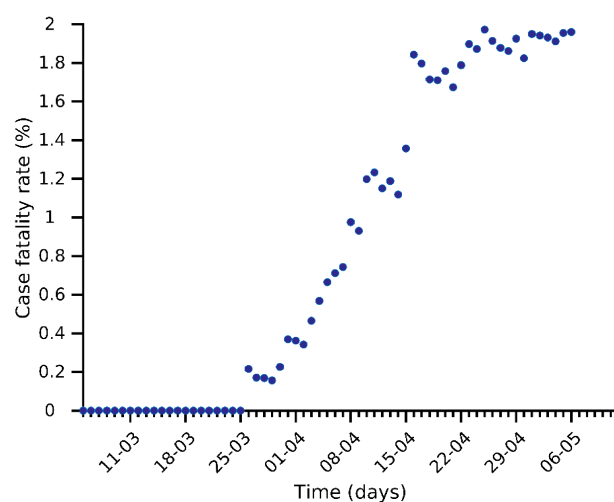
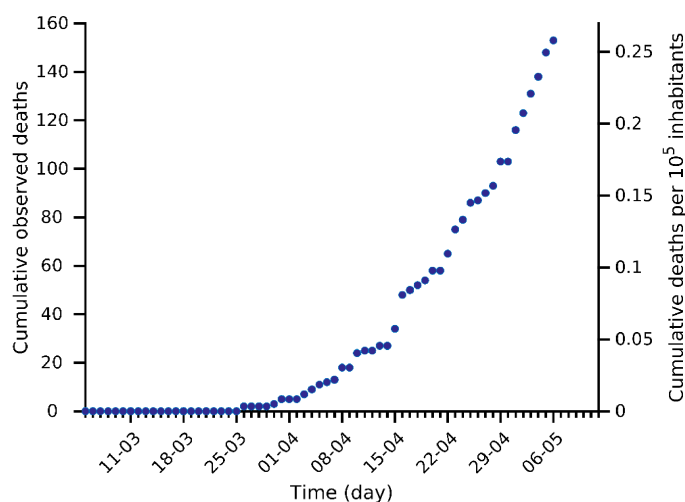
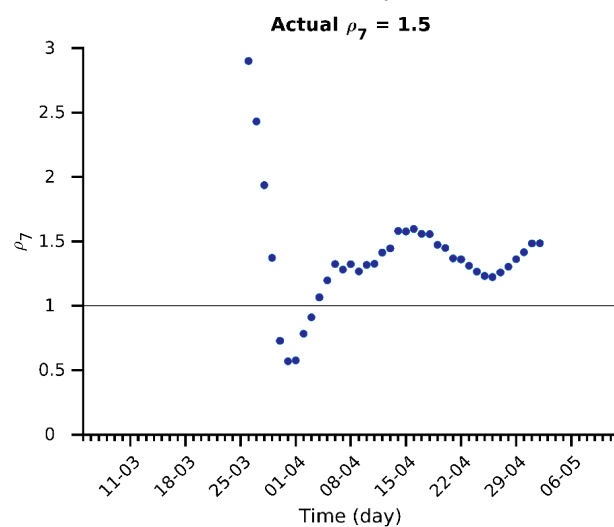
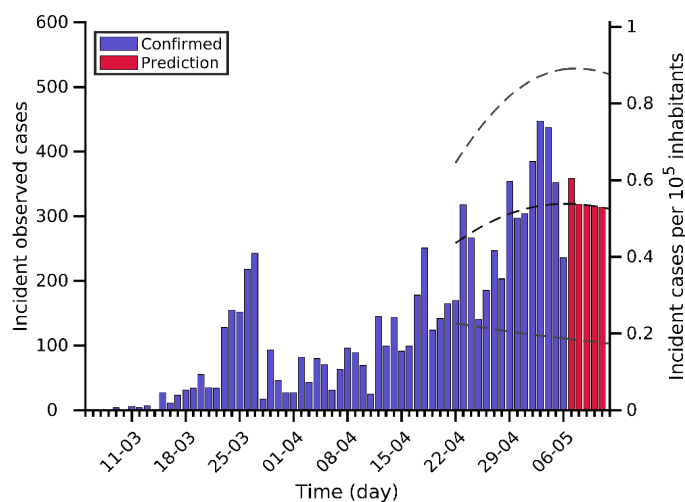
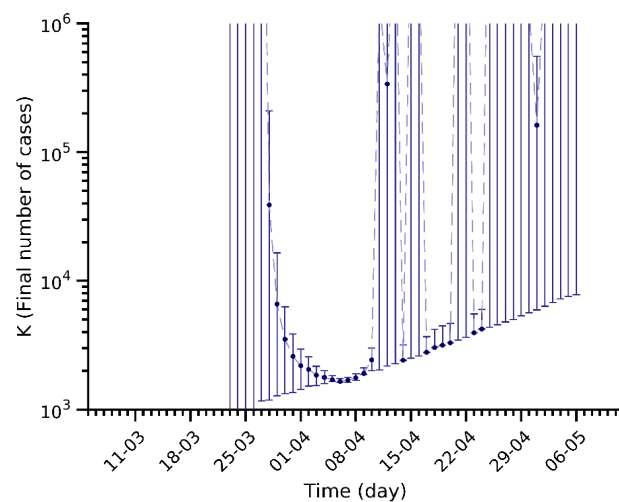
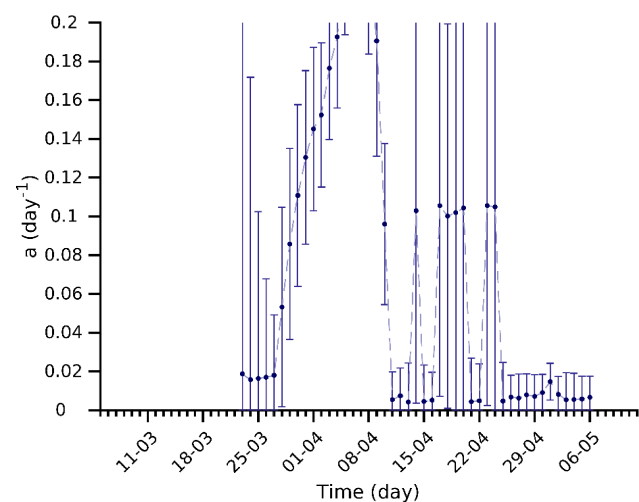
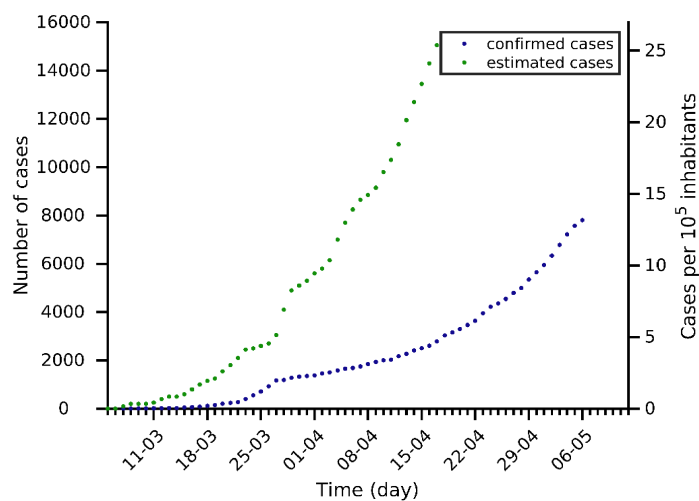
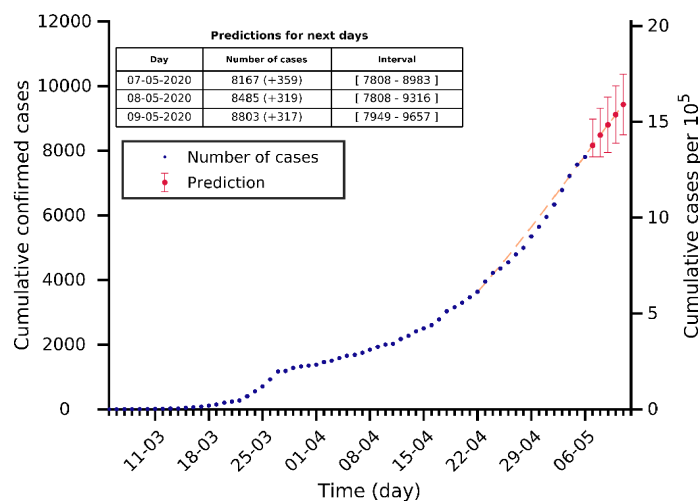
South Korea 06-05-2020. Population: 51.3M. Current cumulated incidence: 21/10⁵



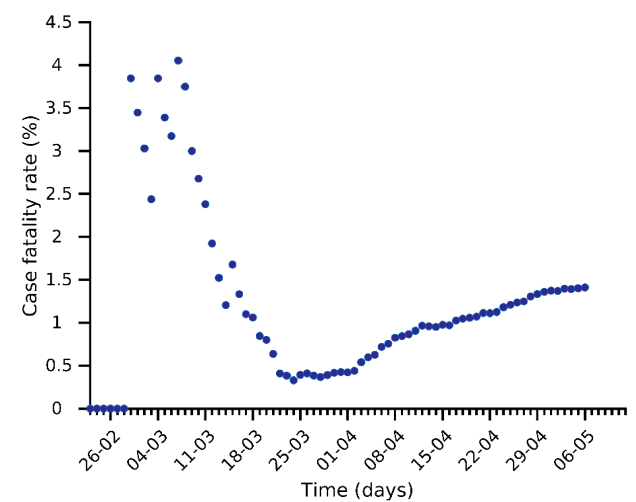
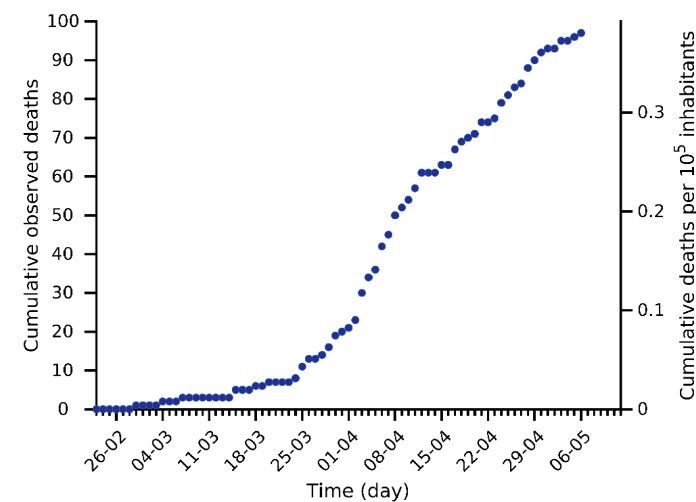
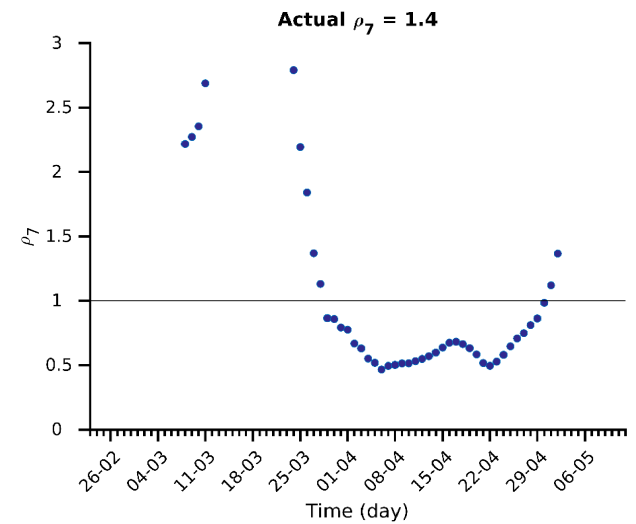
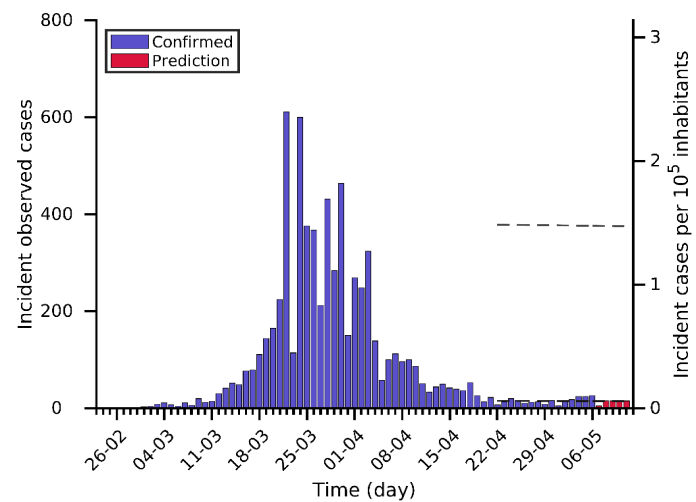
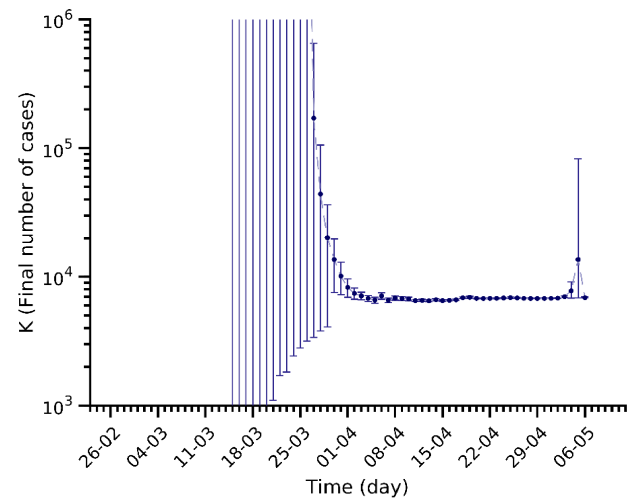
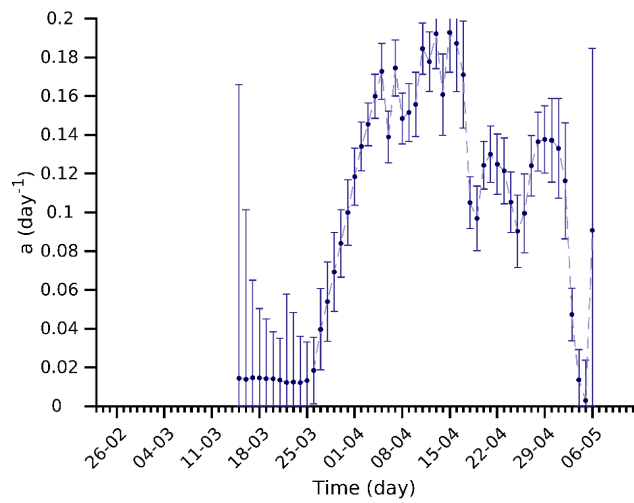
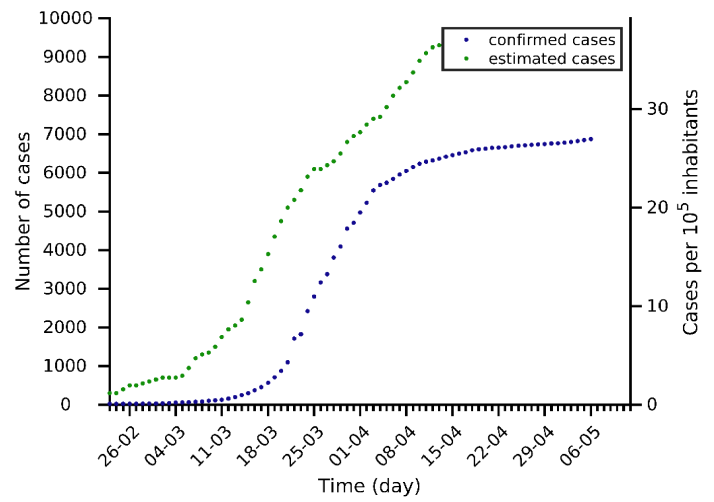
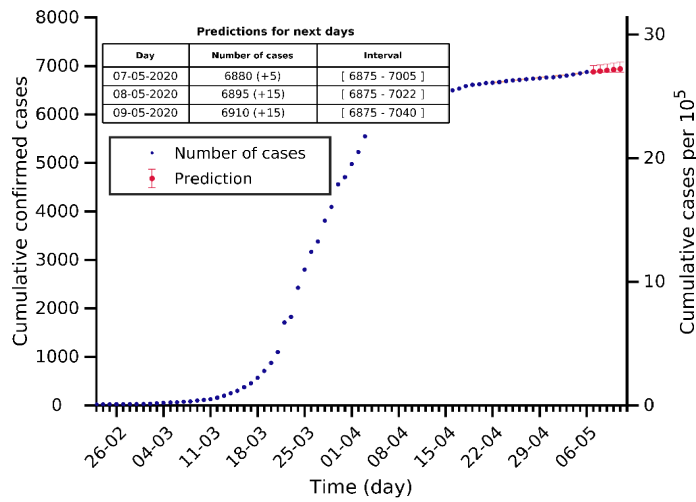
Philippines 06-05-2020. Population: 109.6M. Current cumulated incidence: 9/10⁵



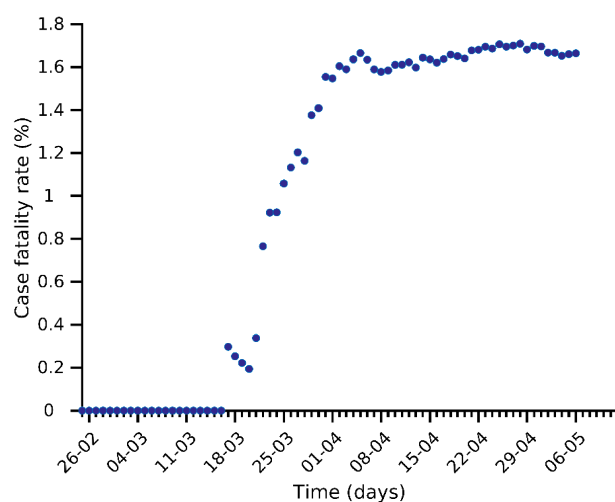
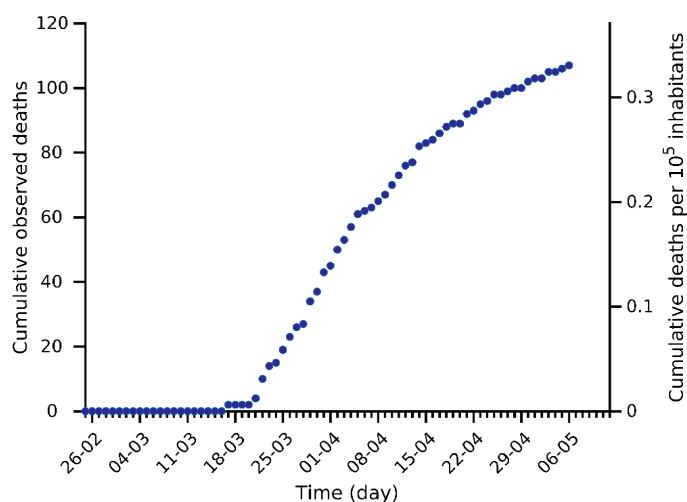
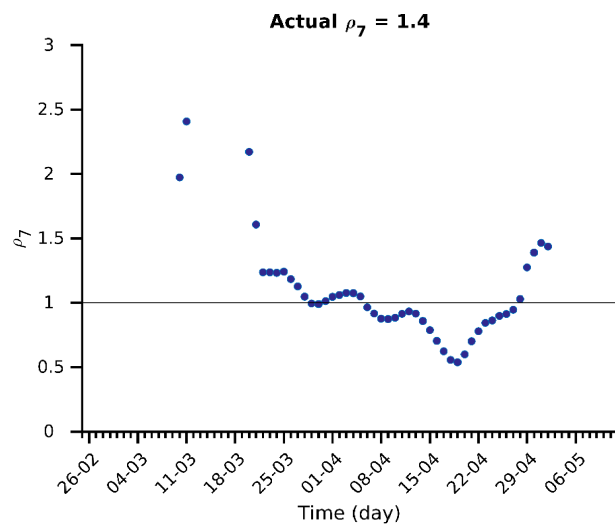
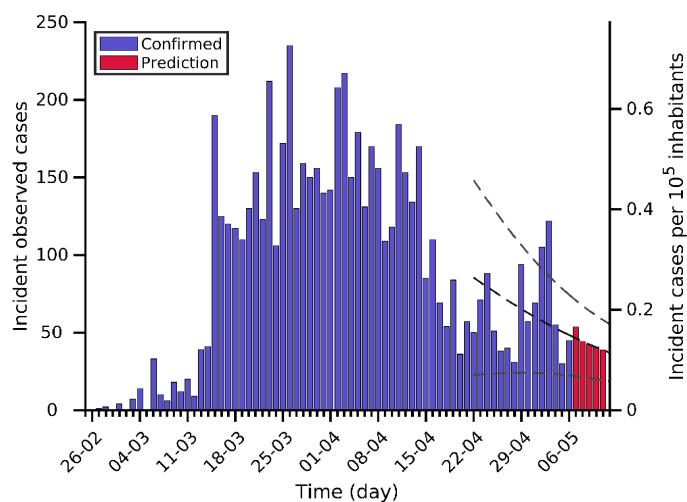
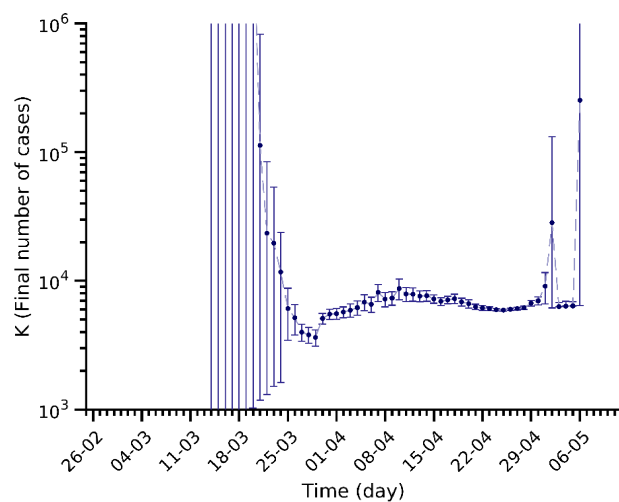
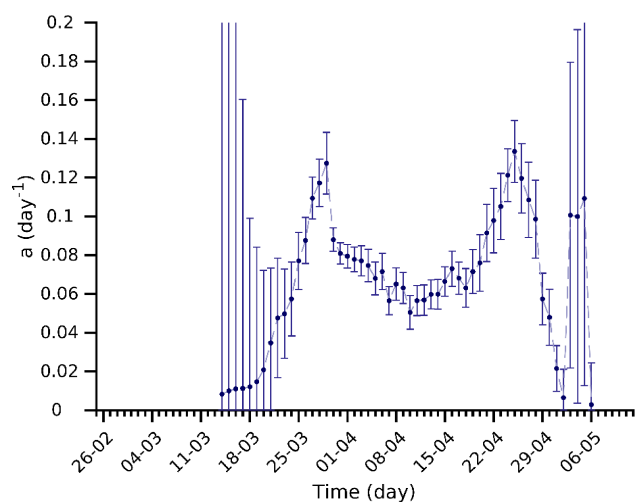
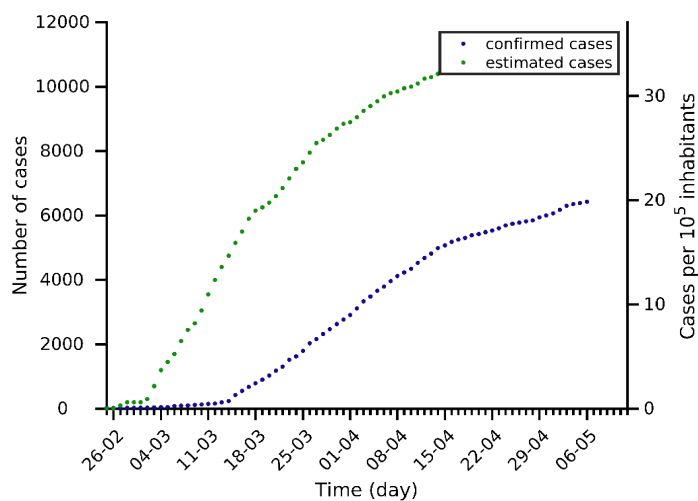
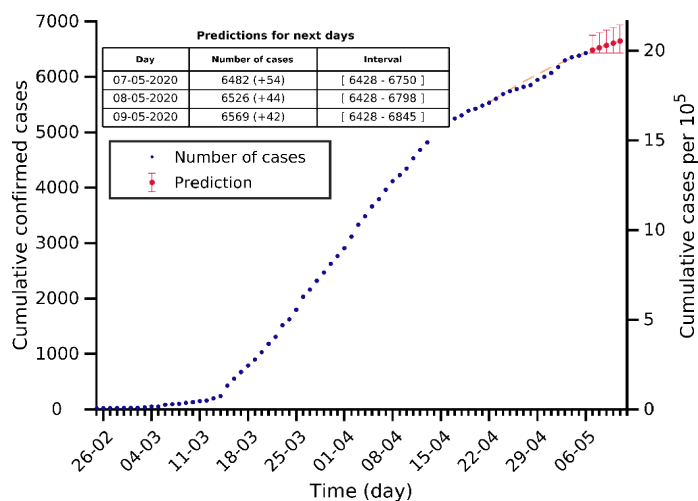
South Africa 06-05-2020. Population: 59.3M. Current cumulated incidence: 13/10⁵



Australia 06-05-2020. Population: 25.5M. Current cumulated incidence: 27/10⁵



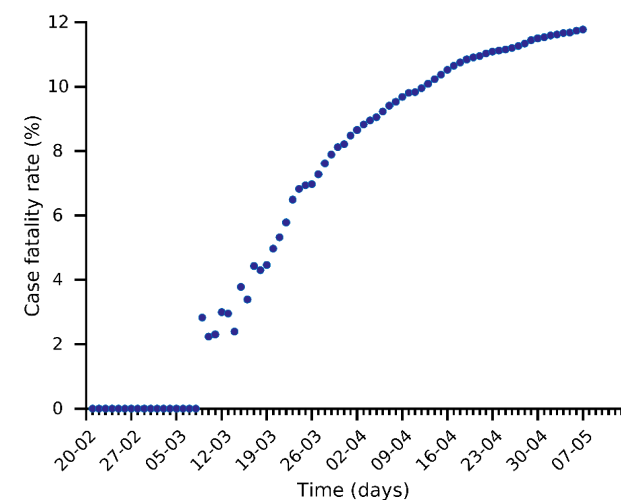
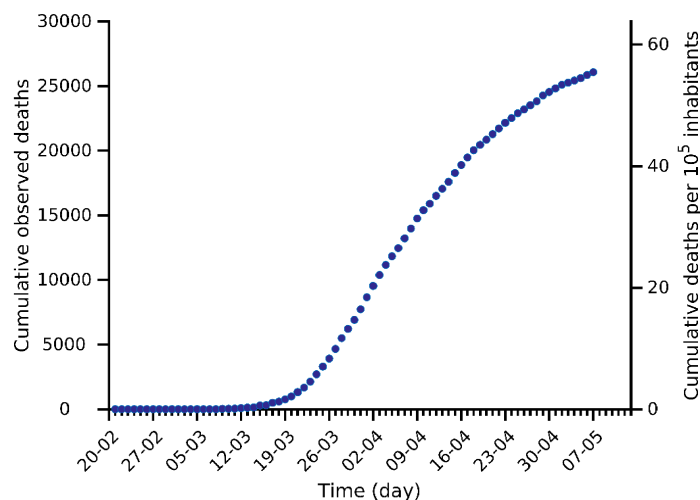
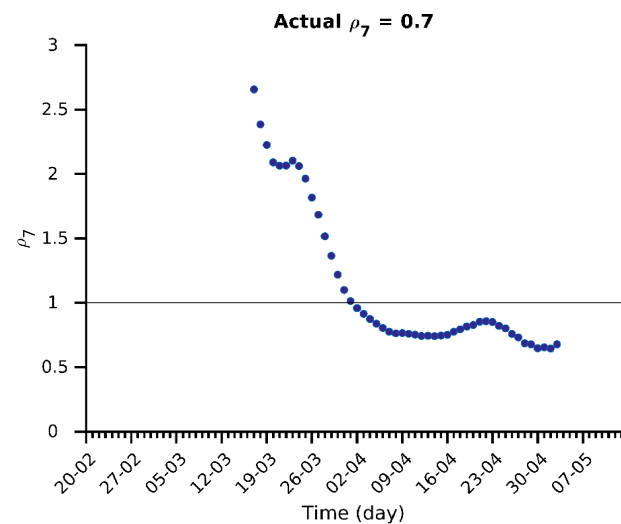
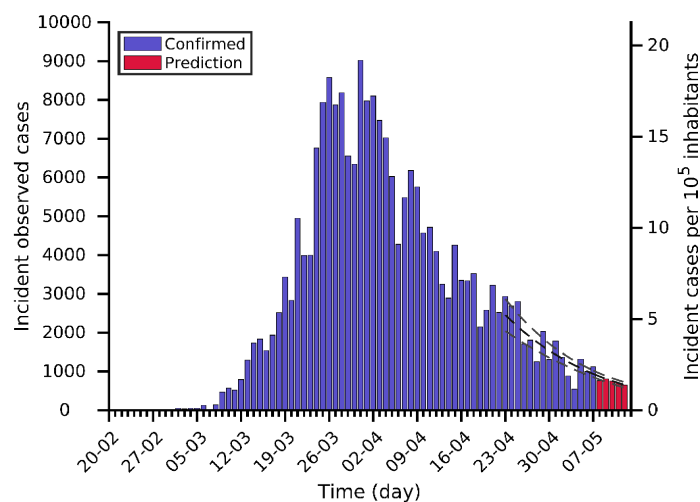
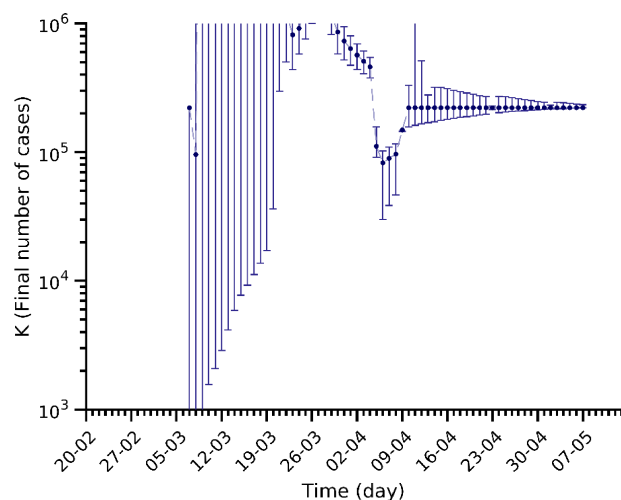
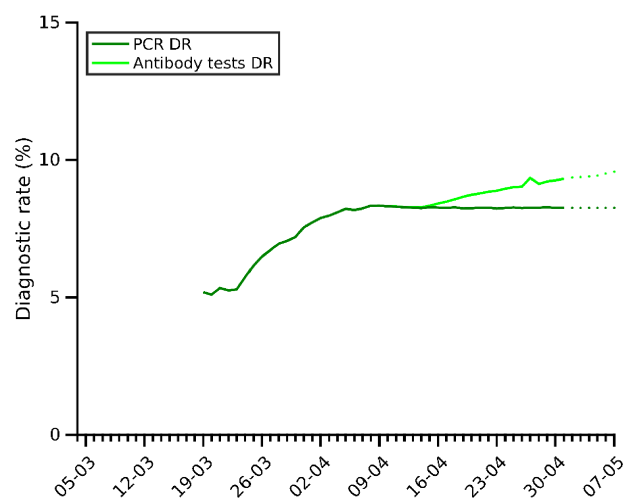
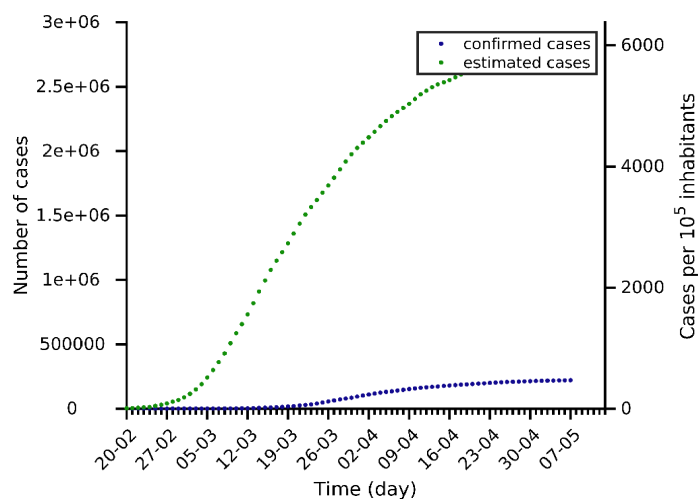
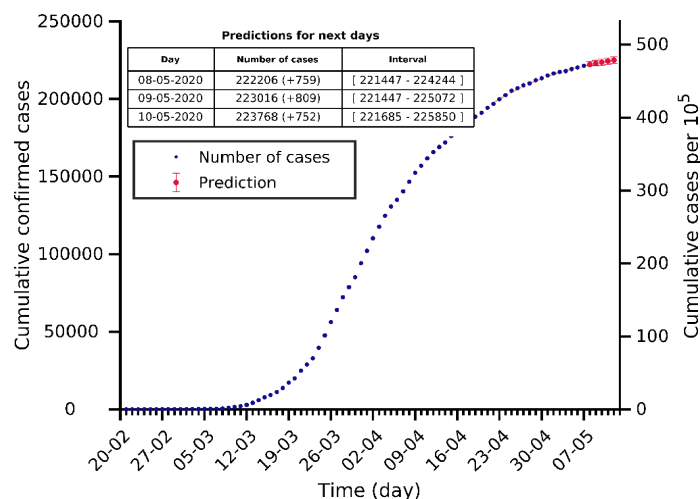
Malaysia 06-05-2020. Population: 32.4M. Current cumulated incidence: 20/10⁵



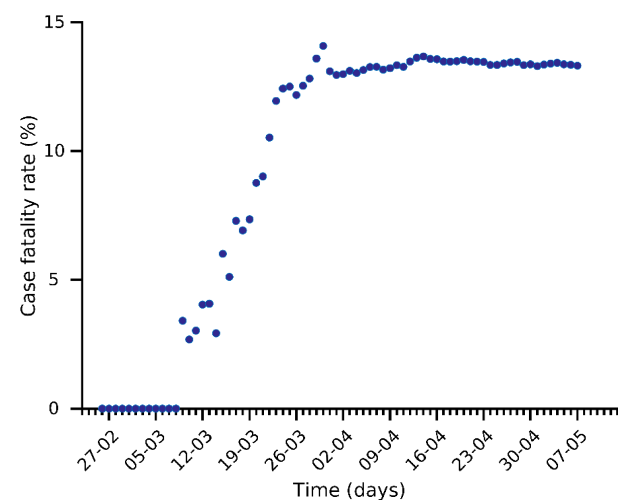
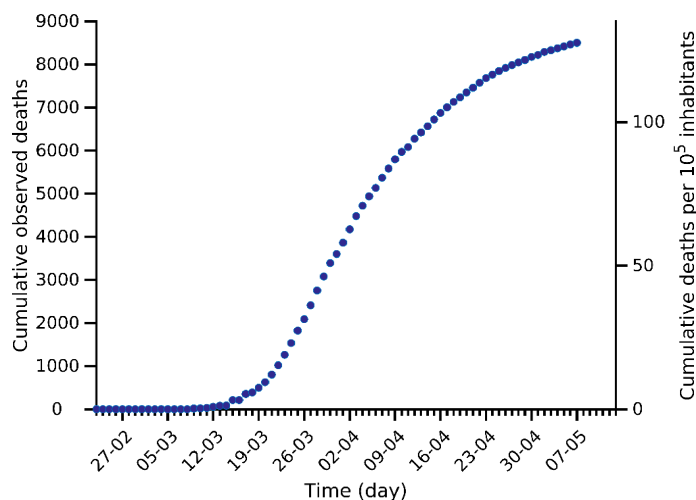
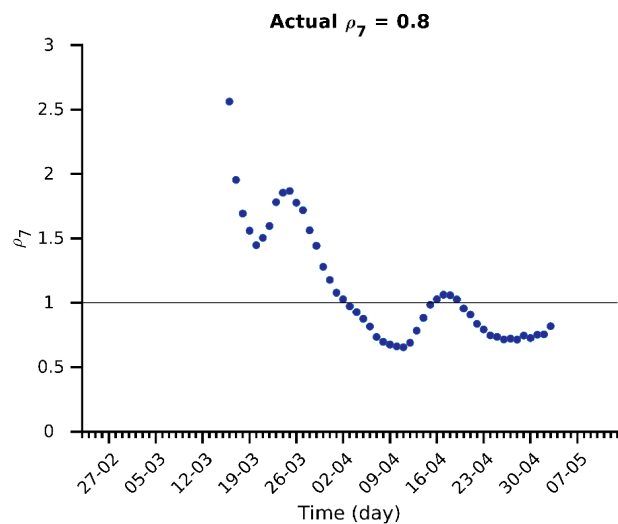
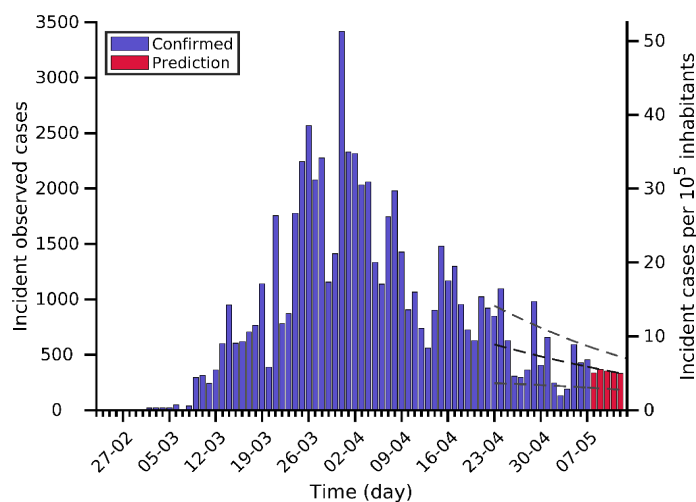
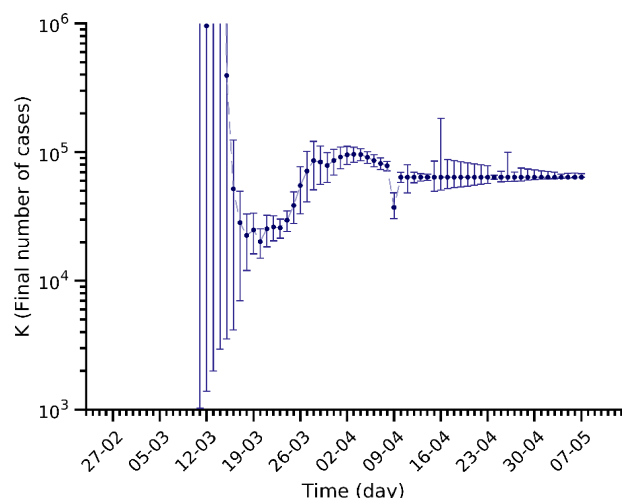
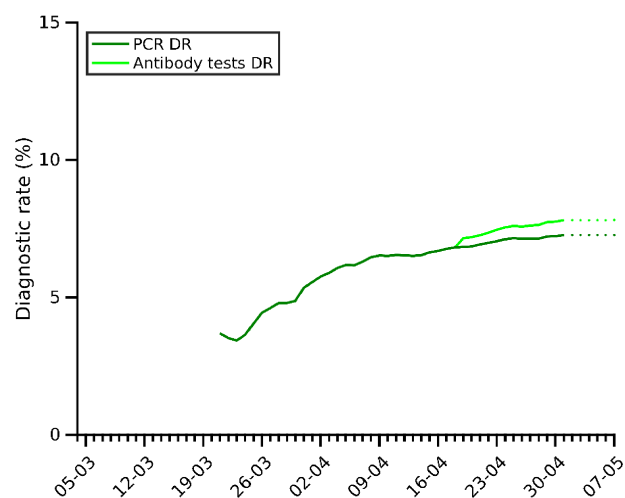
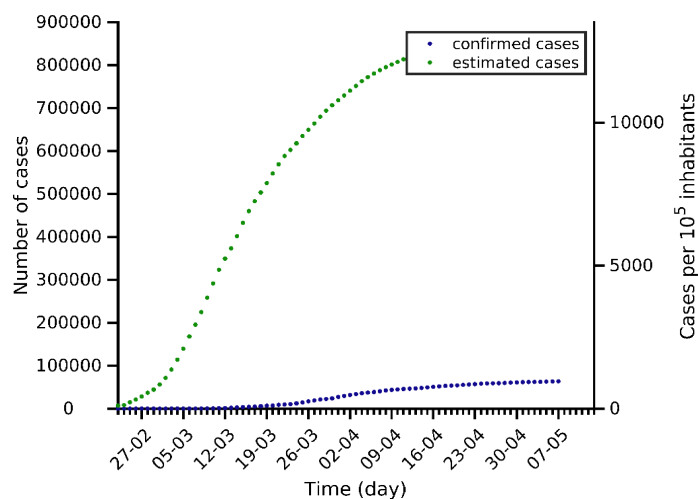
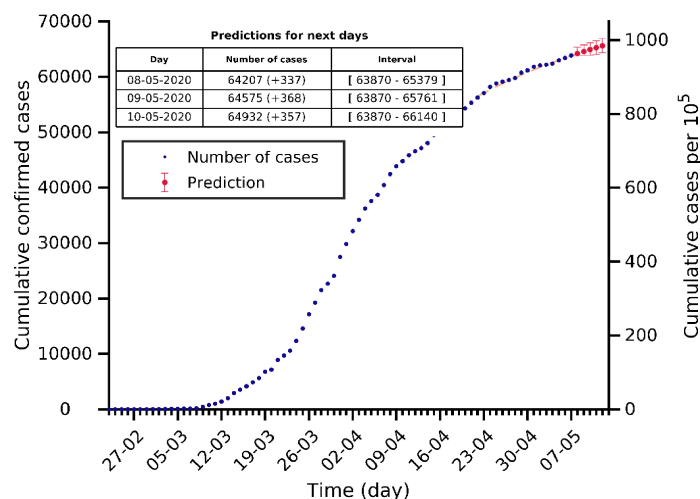
(3) Analysis and prediction of COVID-19 for Spain and its autonomous communities

Data obtained from <https://github.com/datadista/datasets/tree/master/COVID%2019> and
<https://covid19.isciii.es/>

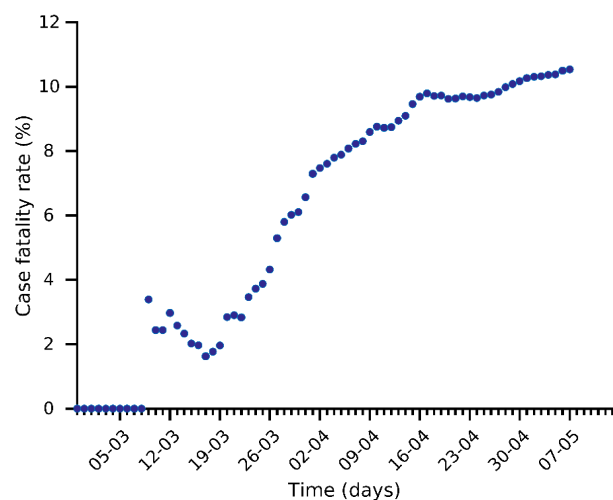
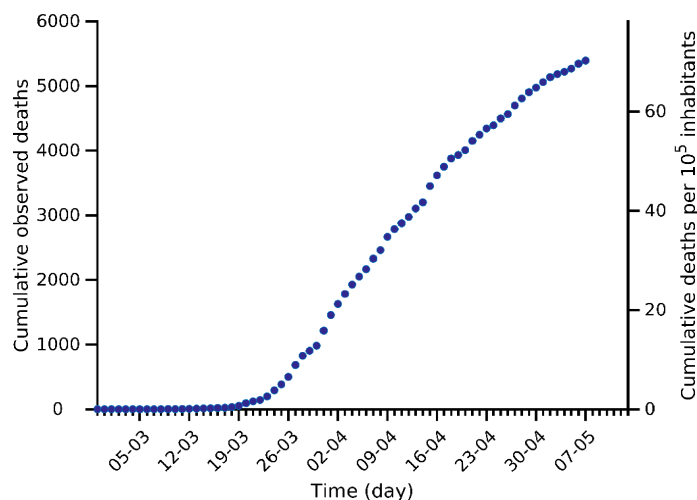
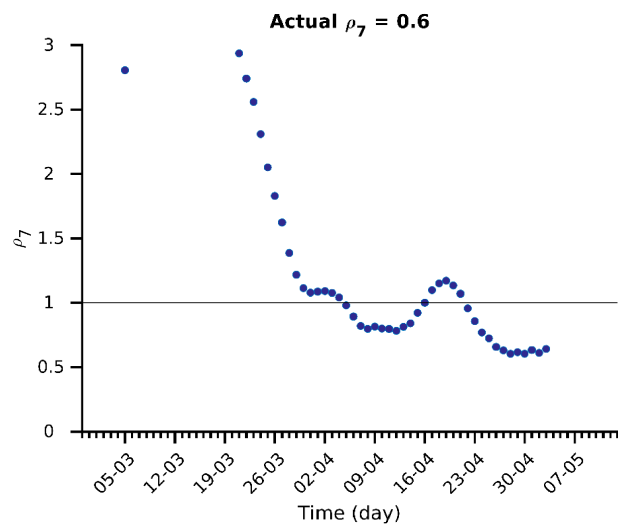
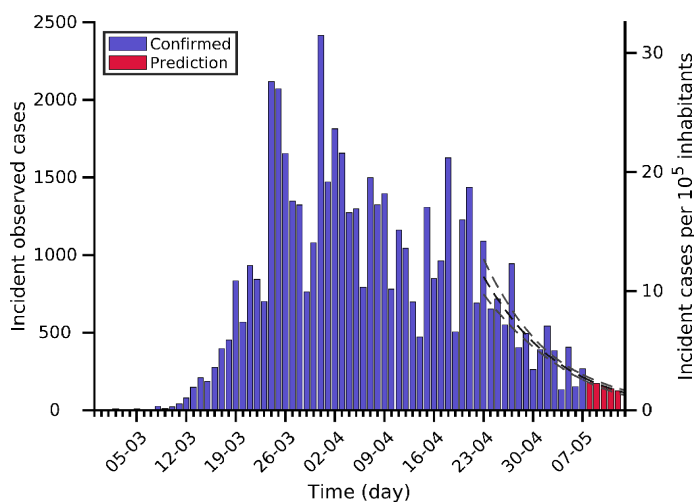
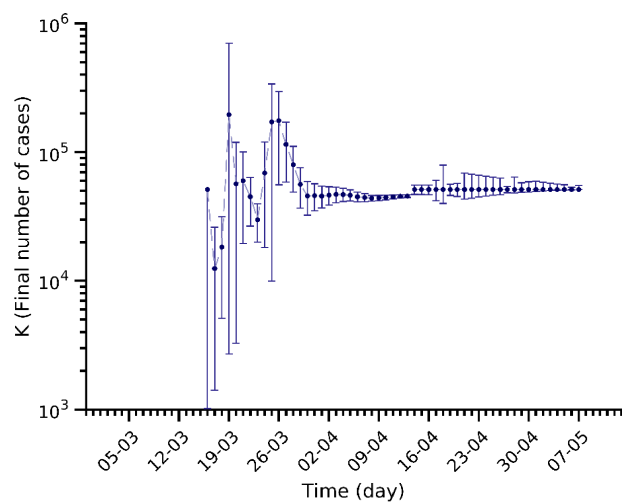
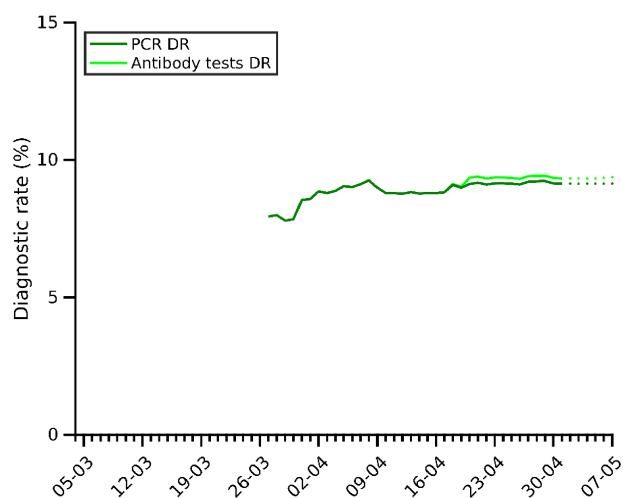
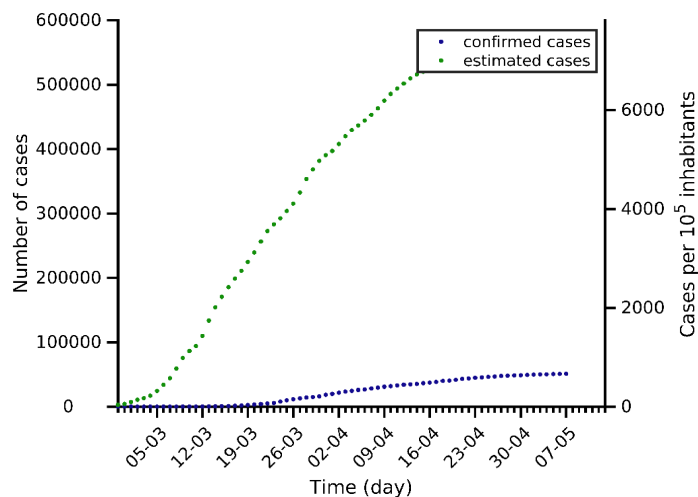
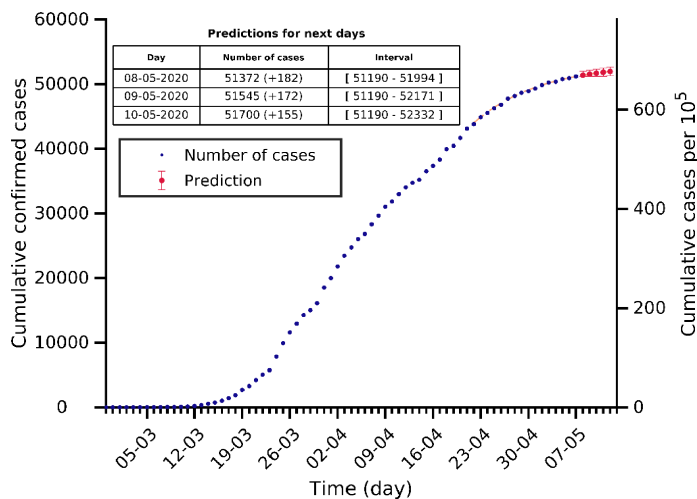
Spain 07-05-2020. Population: 47.0M. Current cumulated incidence: 471/10⁵



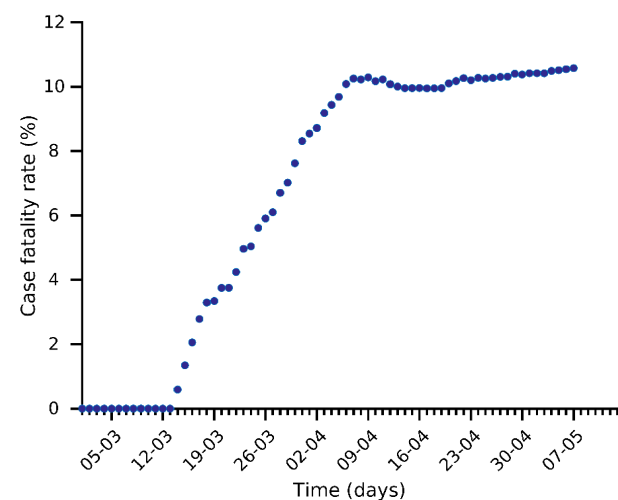
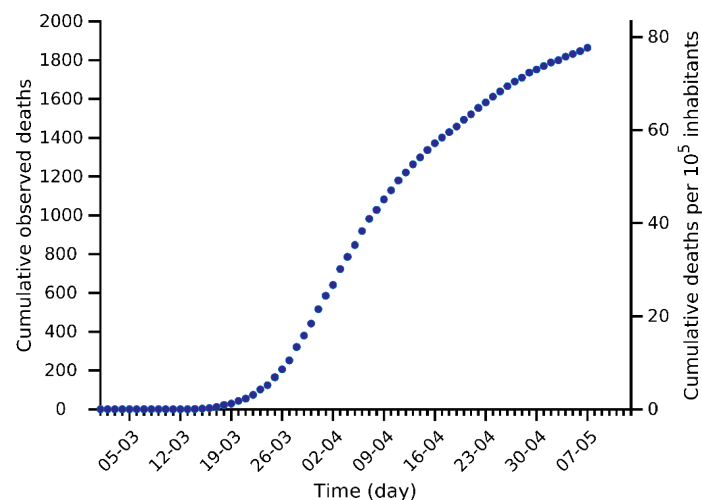
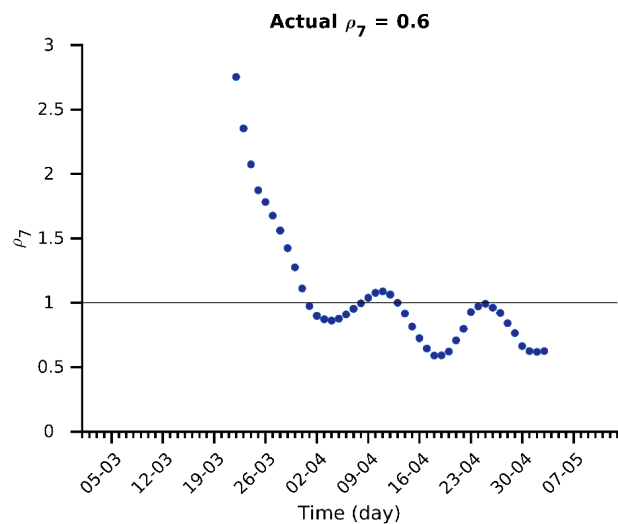
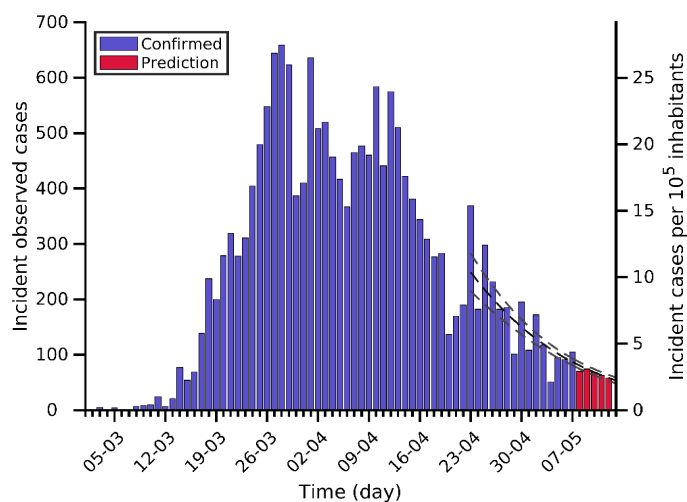
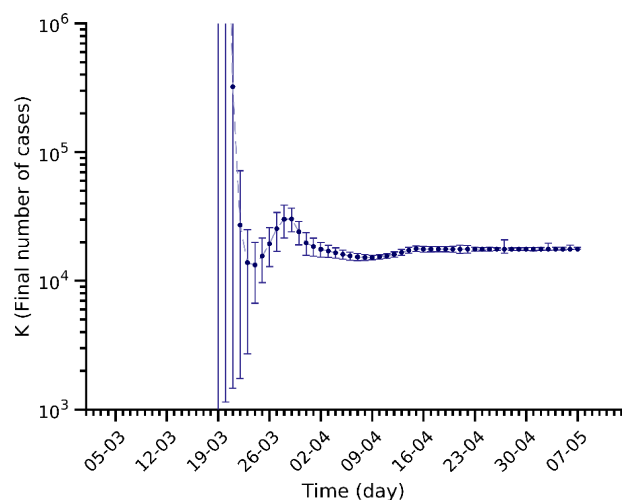
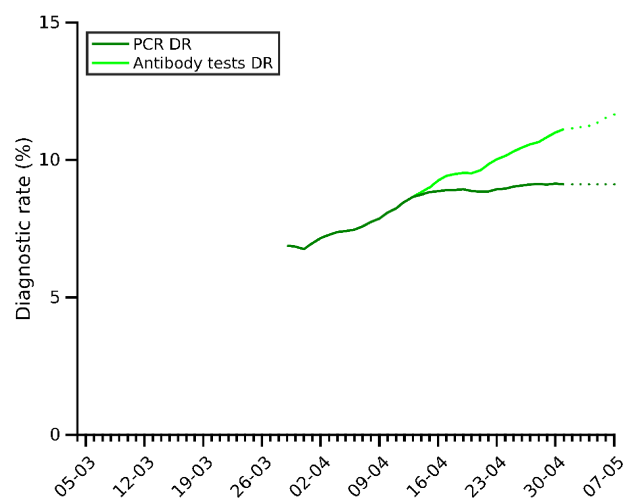
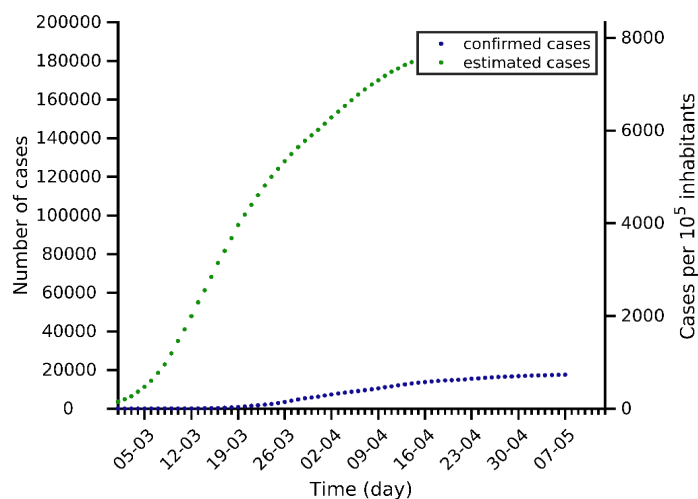
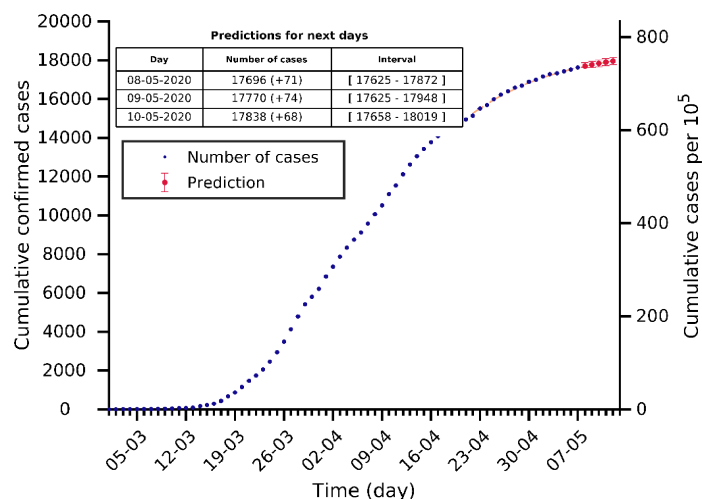
Madrid 07-05-2020. Population: 6.7M. Current cumulated incidence: 959/10⁵



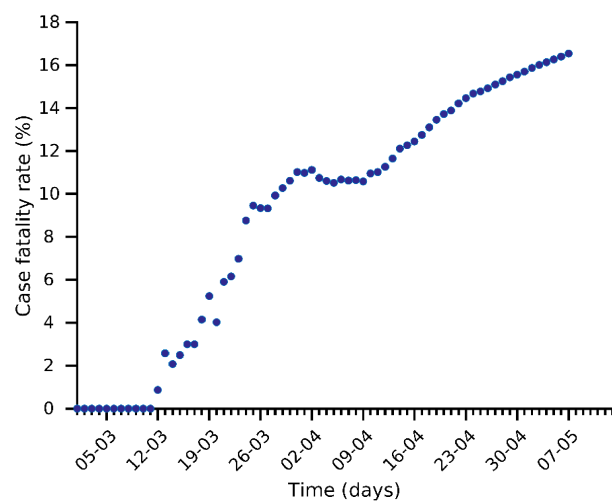
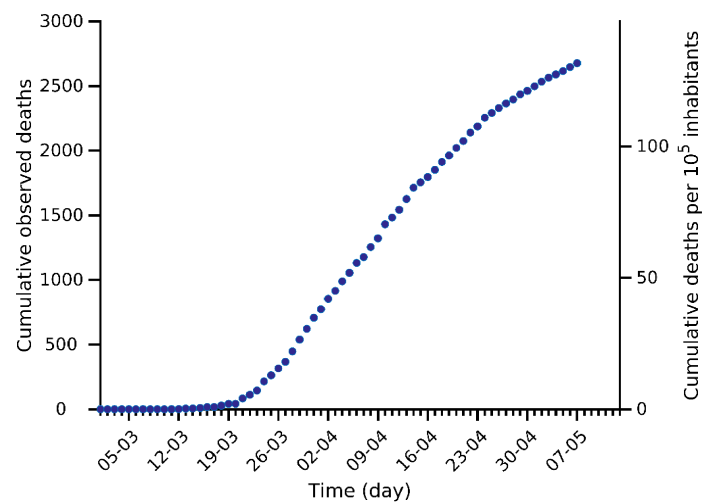
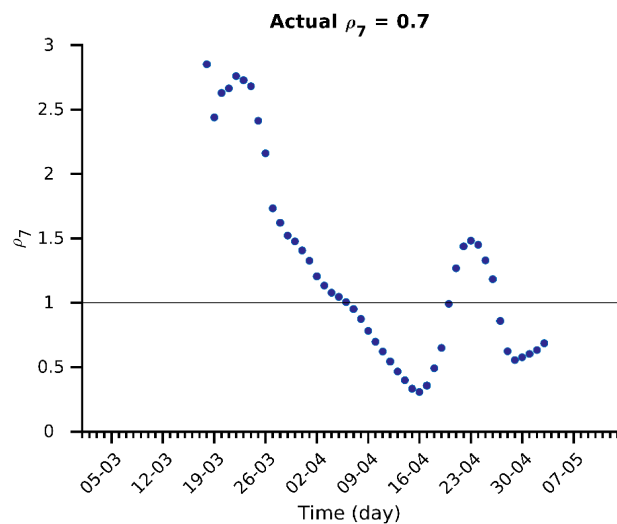
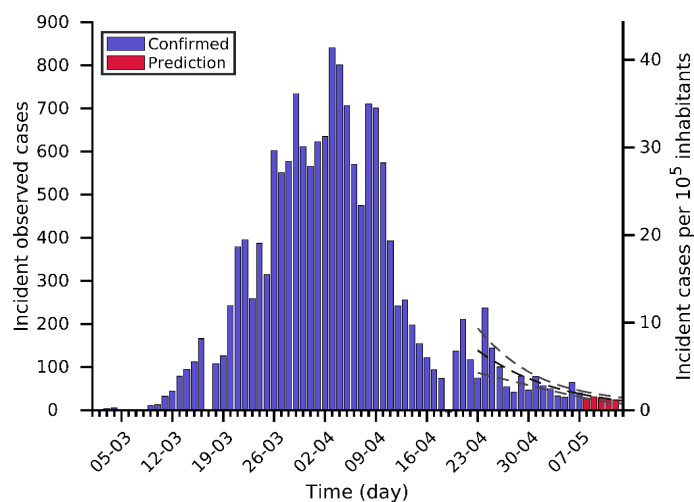
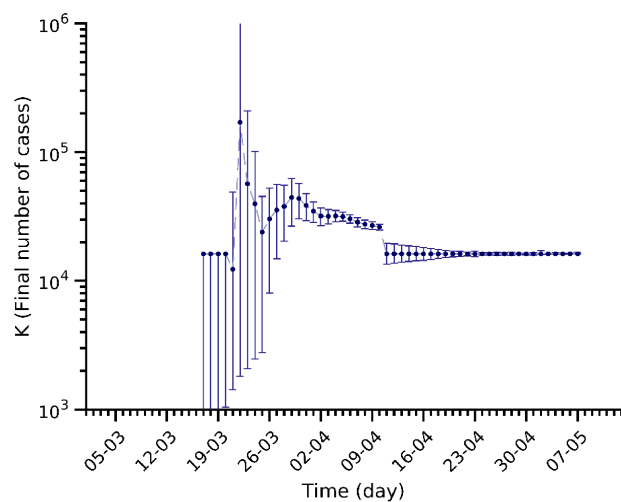
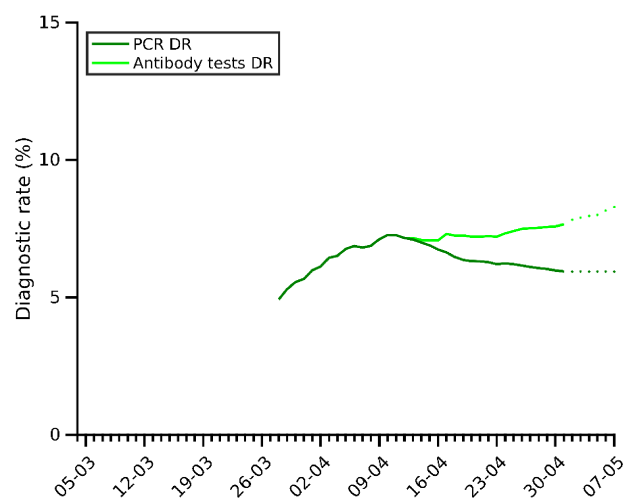
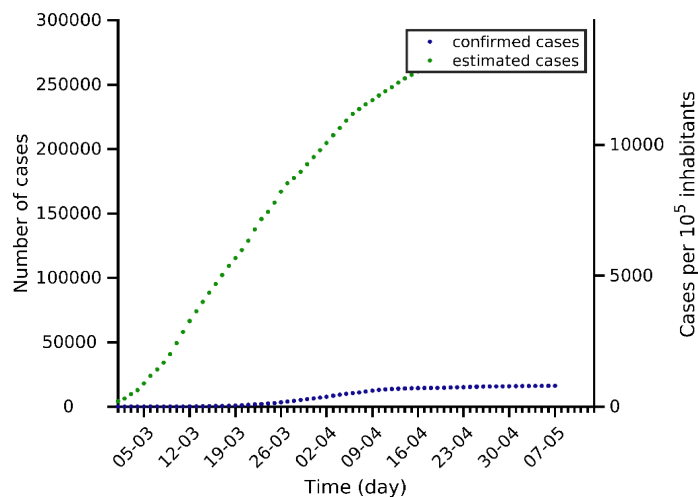
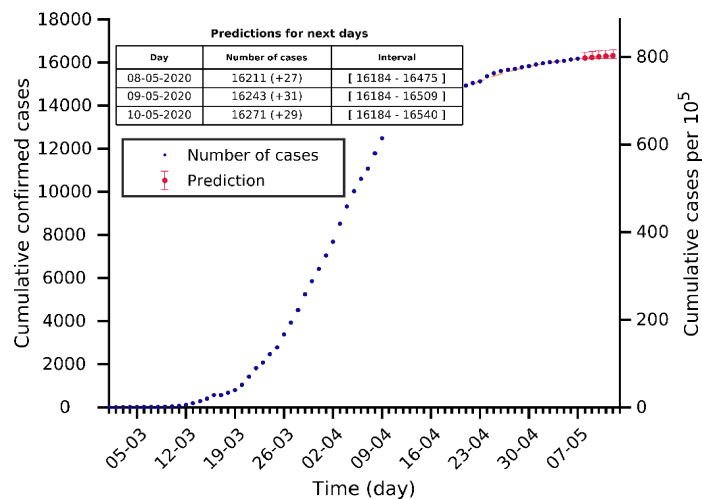
Catalunya 07-05-2020. Population: 7.7M. Current cumulated incidence: 667/10⁵



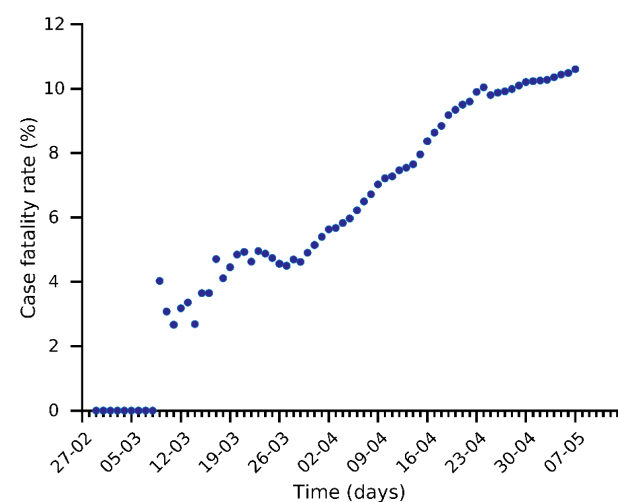
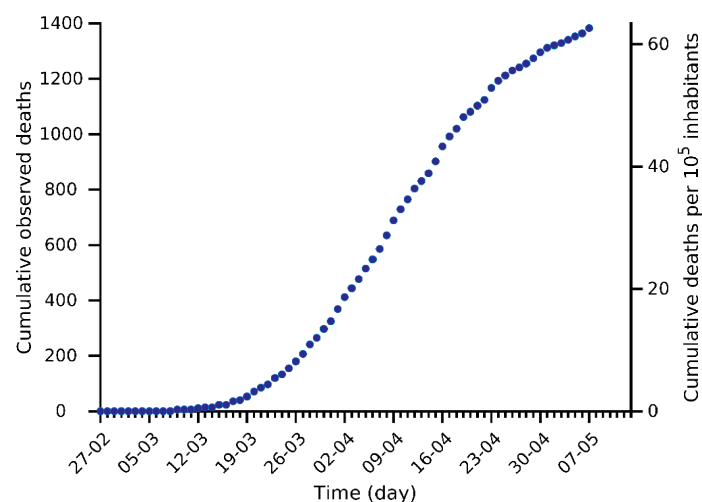
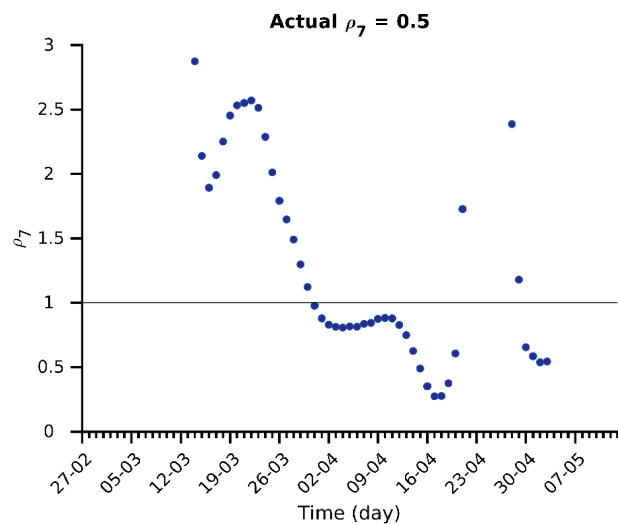
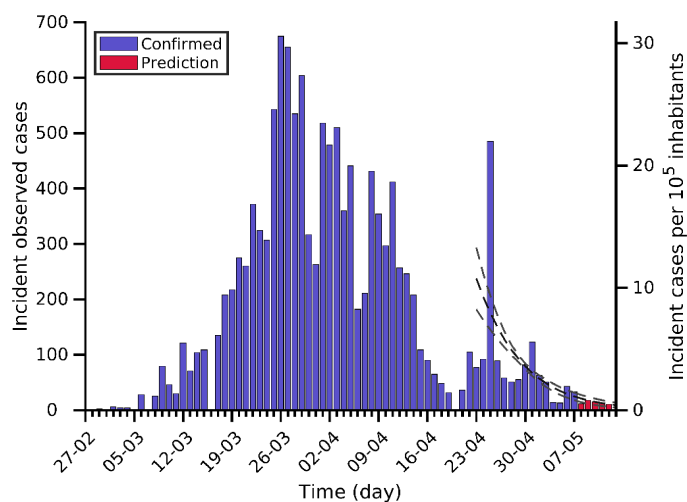
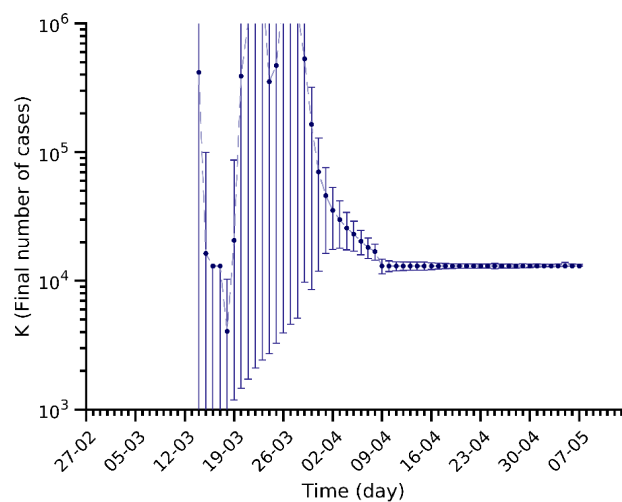
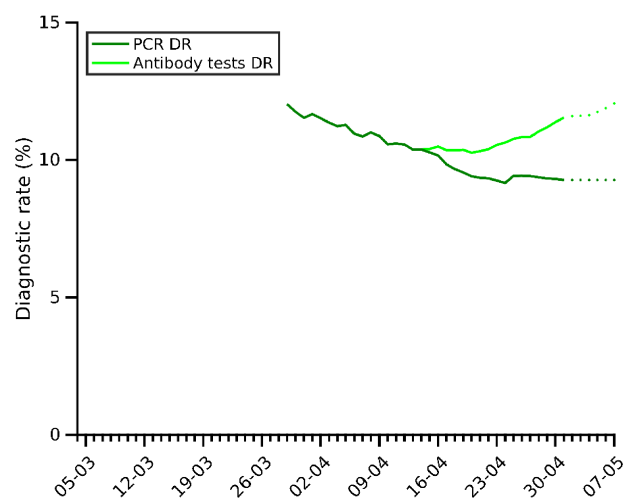
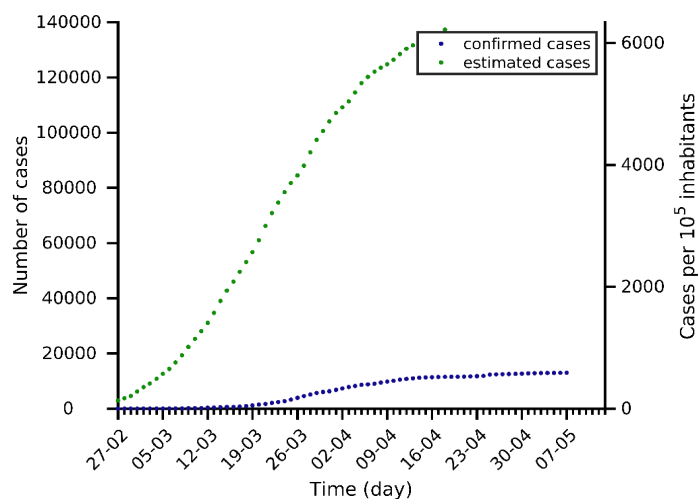
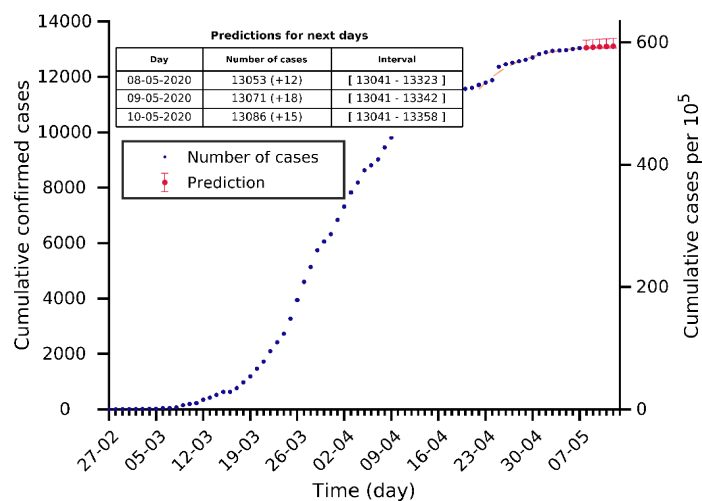
Castilla Leon 07-05-2020. Population: 2.4M. Current cumulated incidence: 735/10⁵



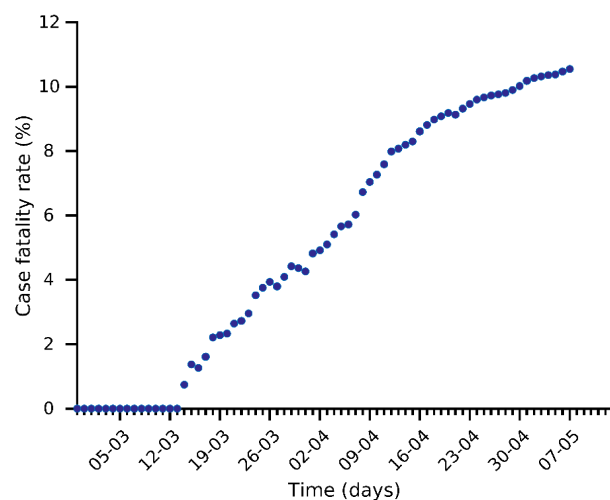
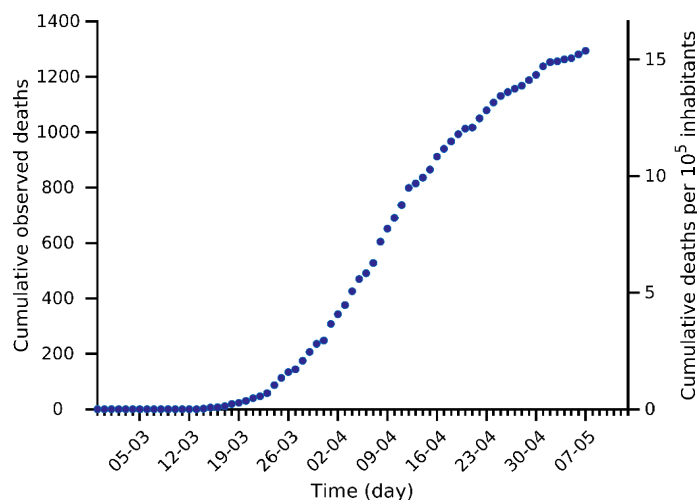
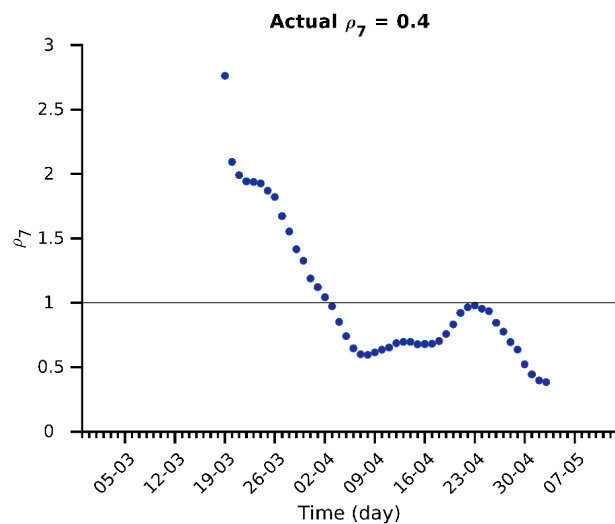
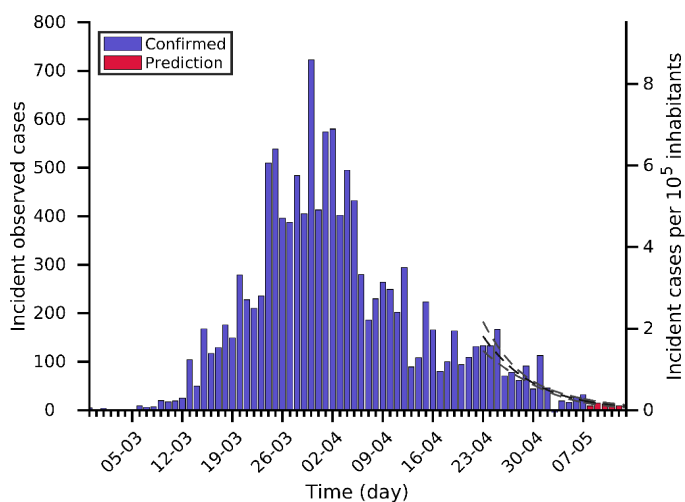
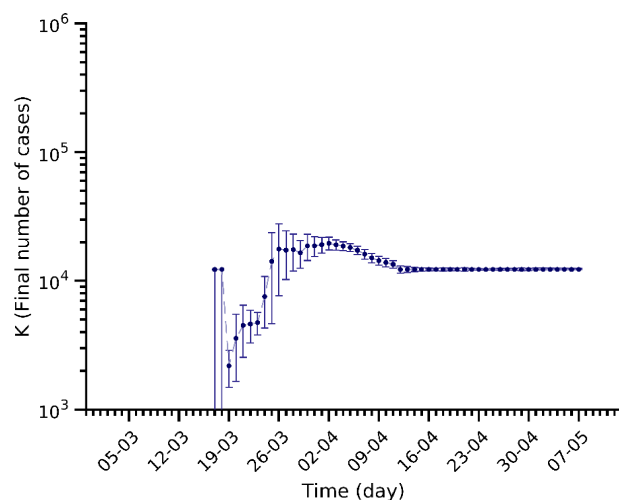
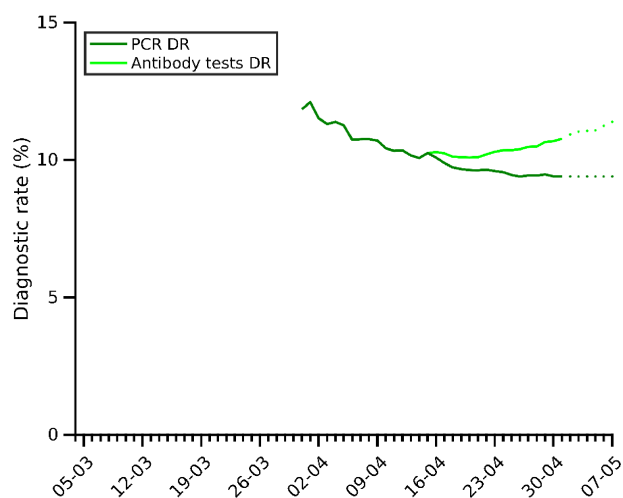
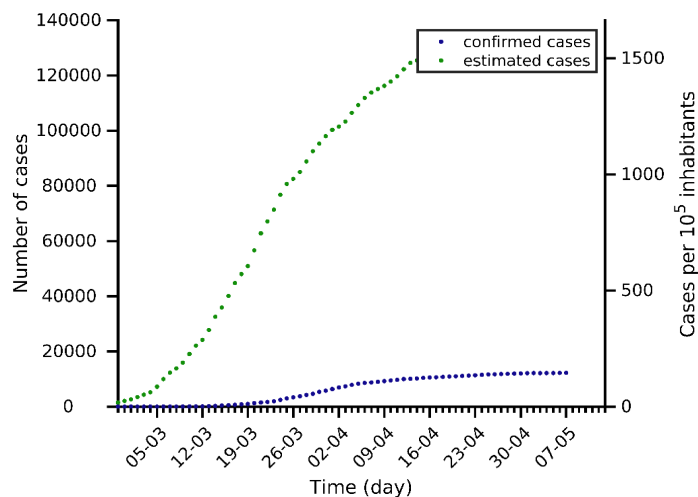
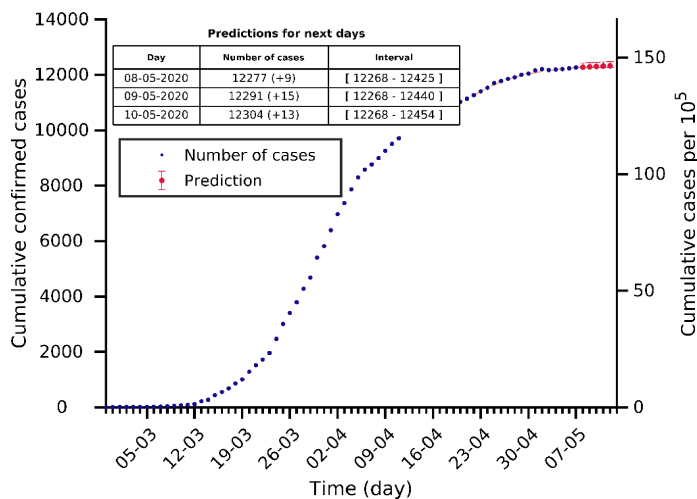
Castilla-La Mancha 07-05-2020. Population: 2.0M. Current cumulated incidence: 79



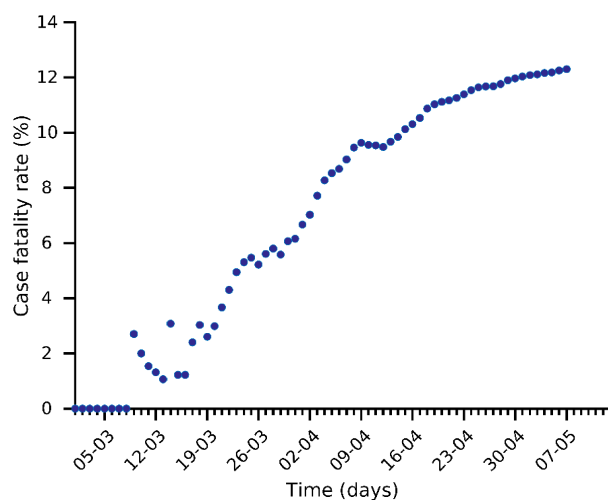
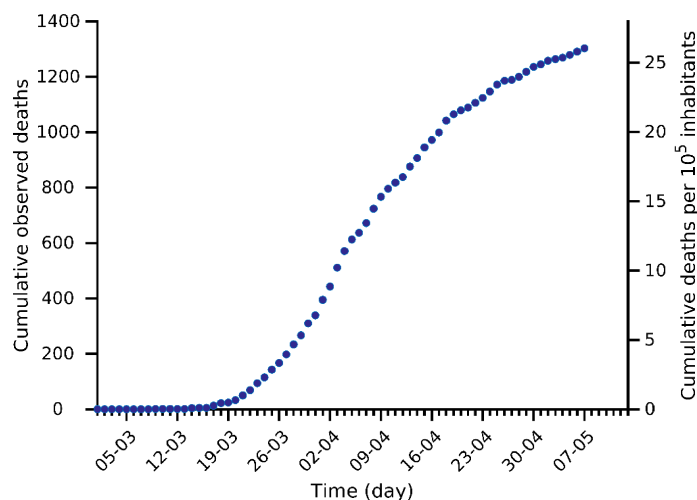
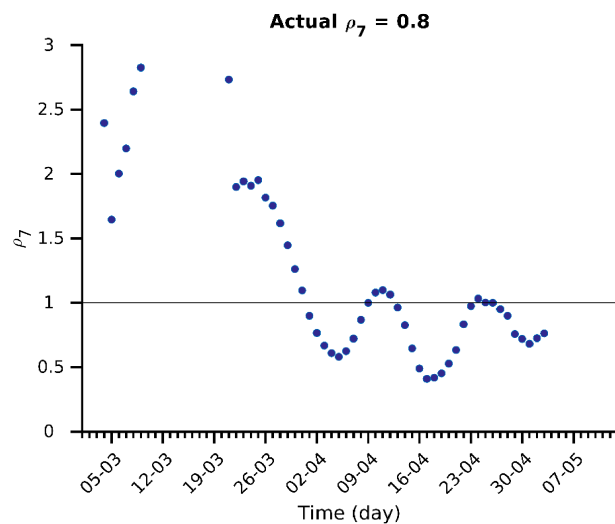
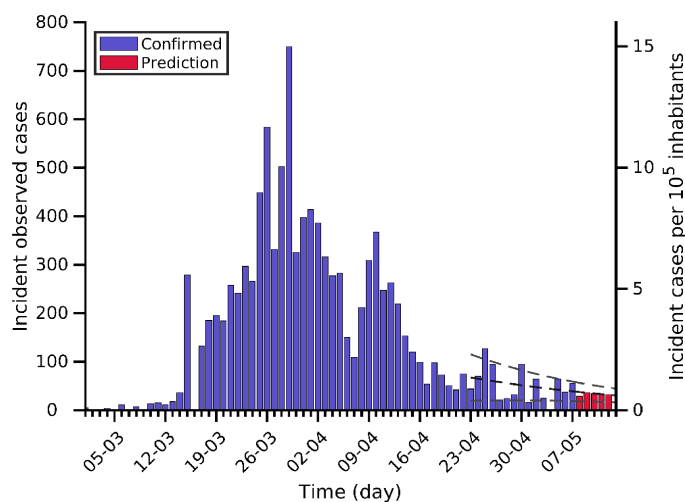
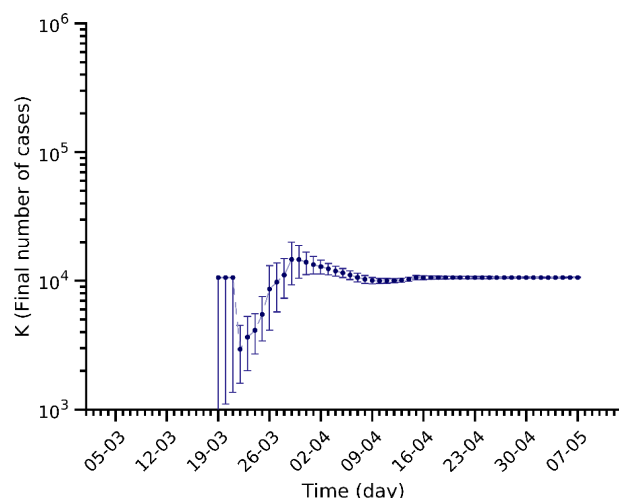
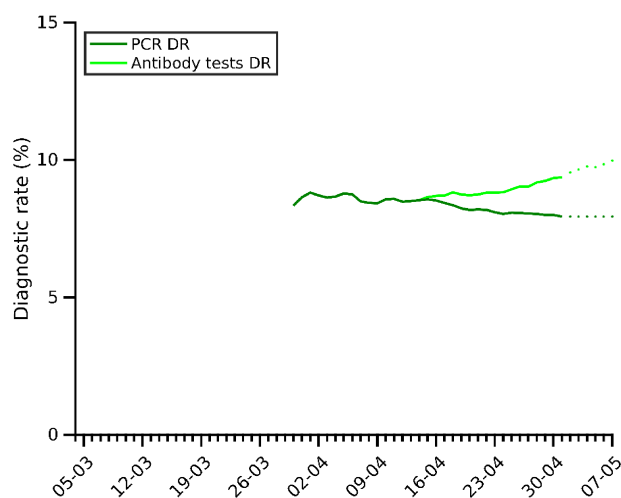
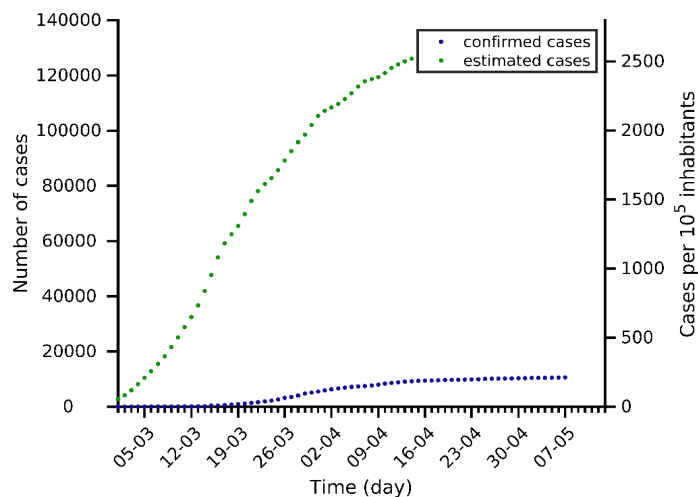
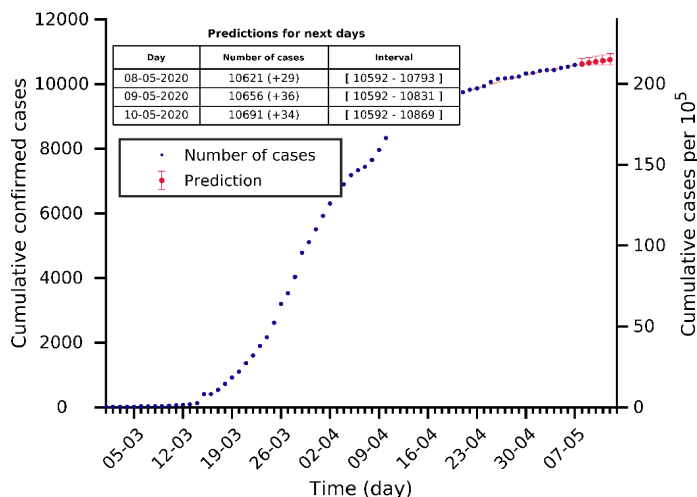
Euskadi 07-05-2020. Population: 2.2M. Current cumulated incidence: 591/10⁵



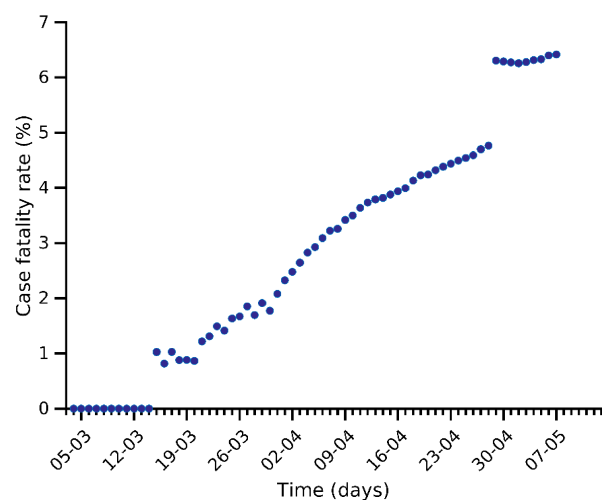
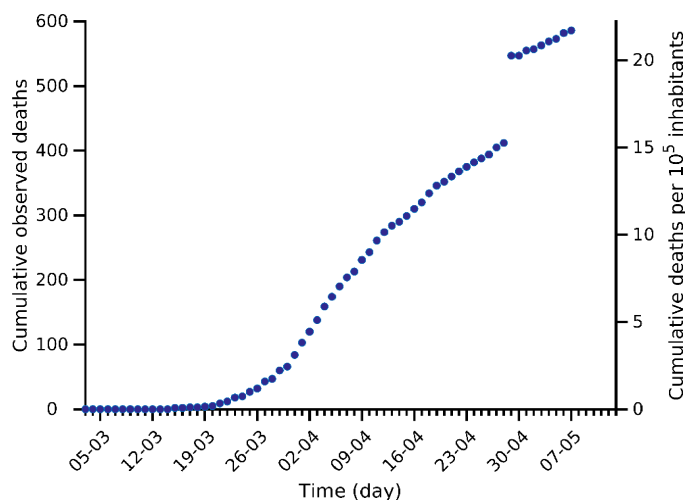
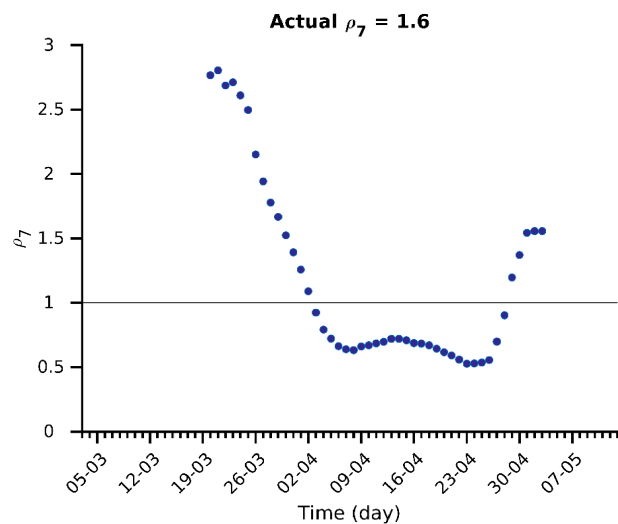
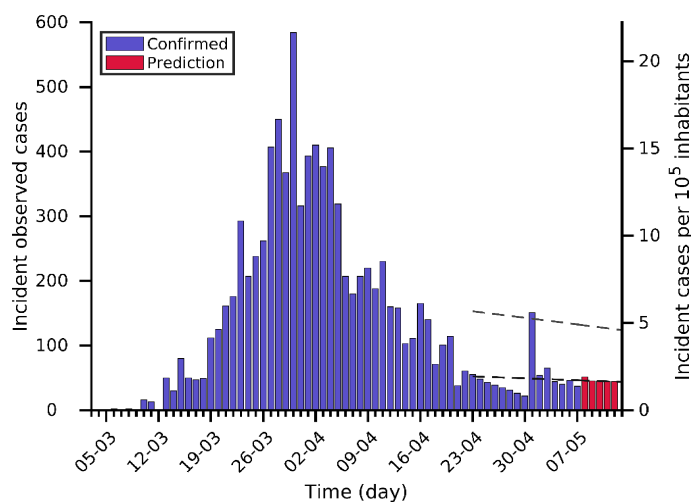
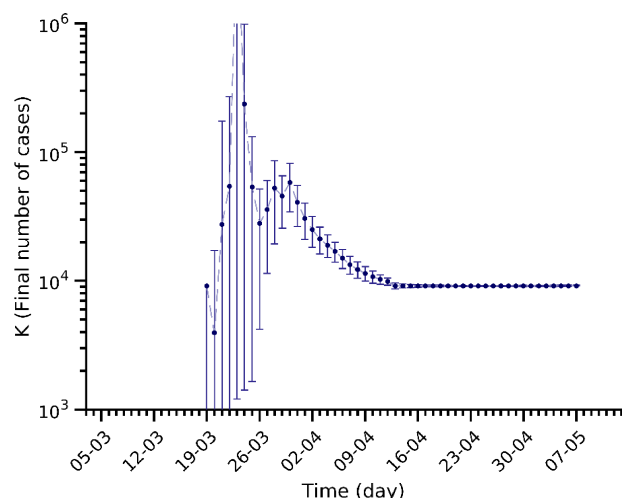
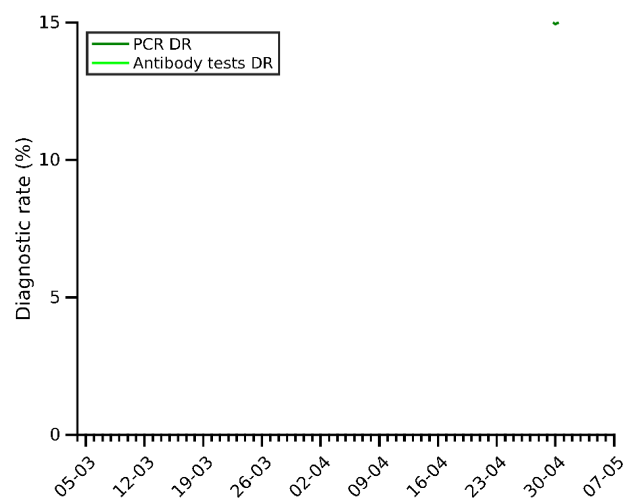
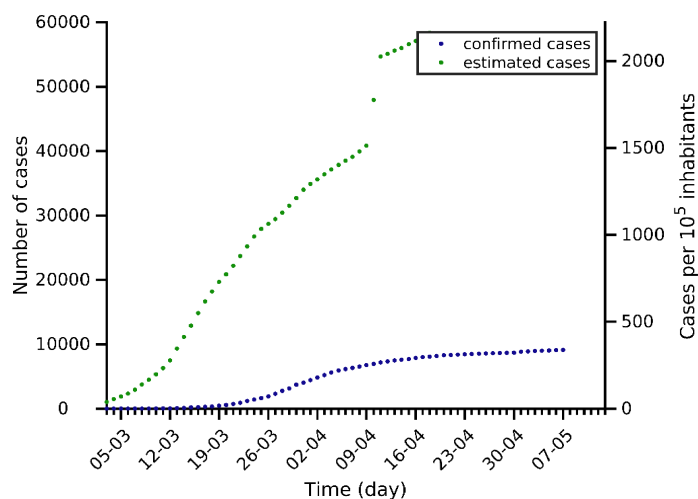
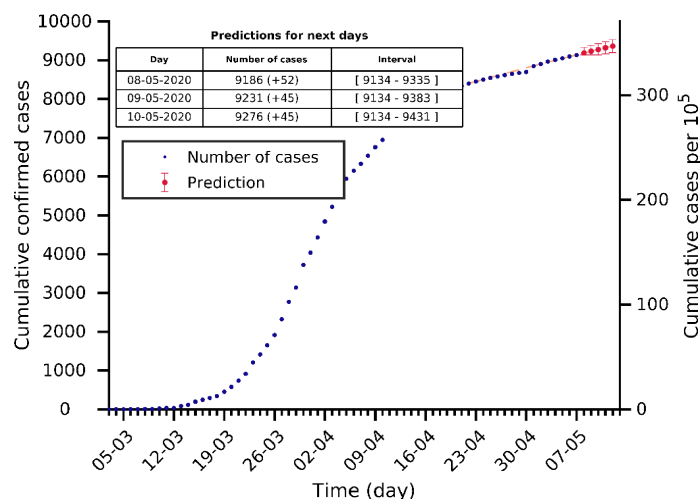
Andalucia 07-05-2020. Population: 8.4M. Current cumulated incidence: 146/10⁵



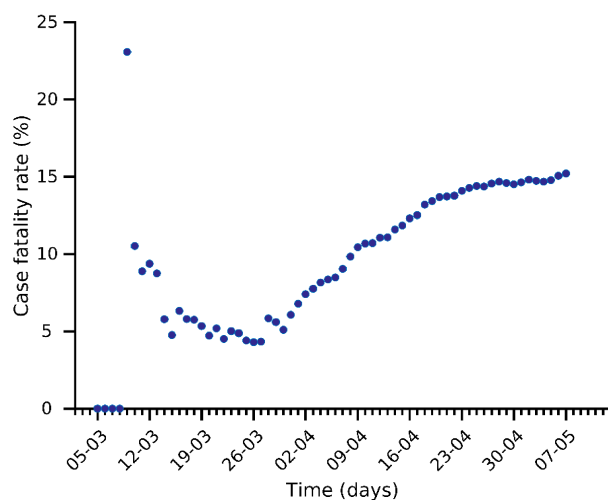
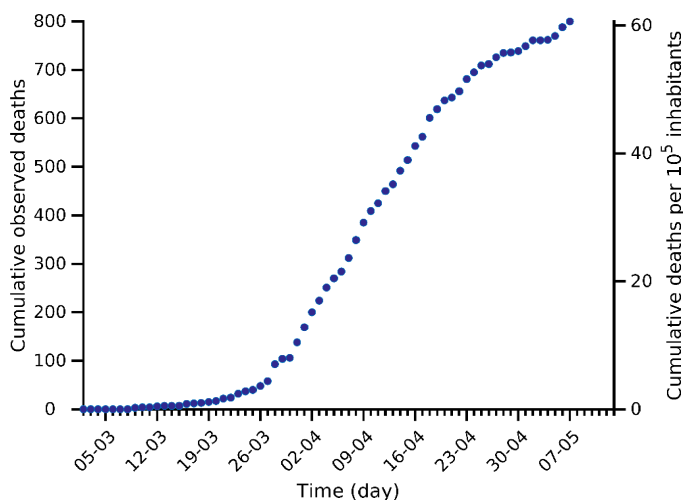
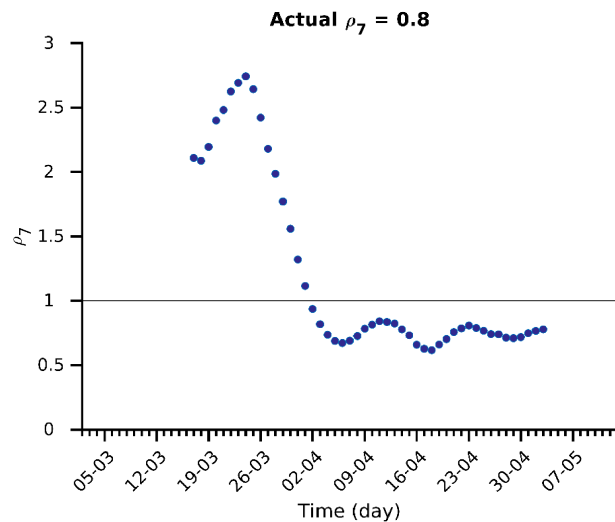
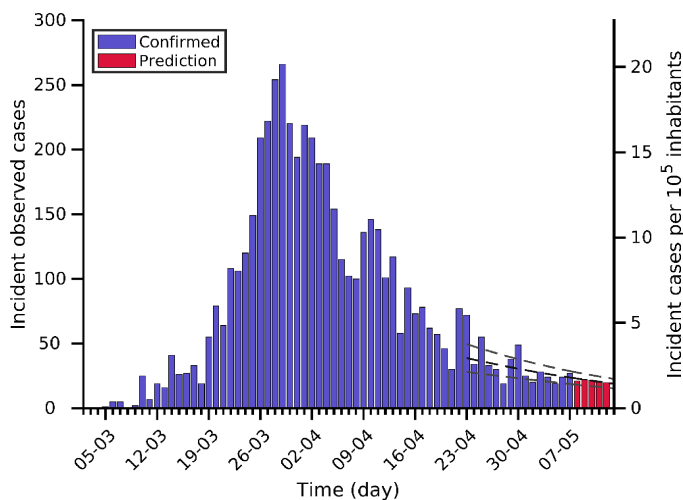
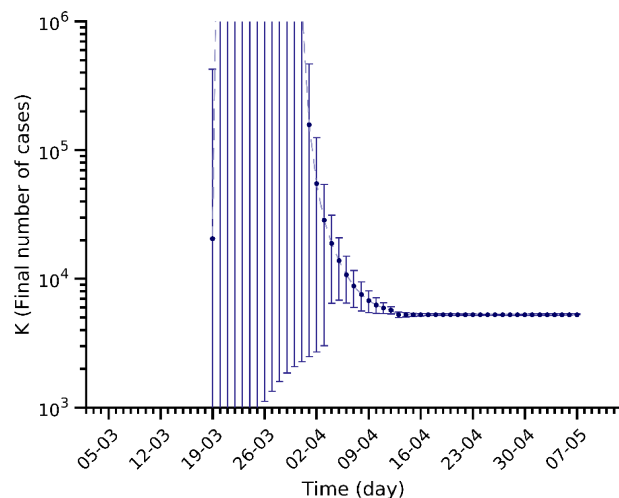
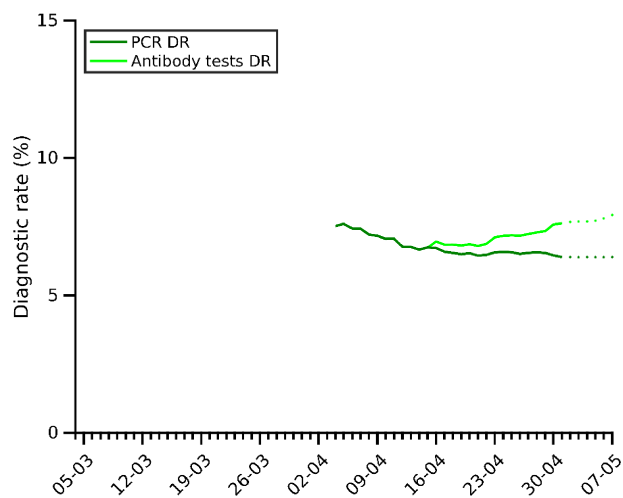
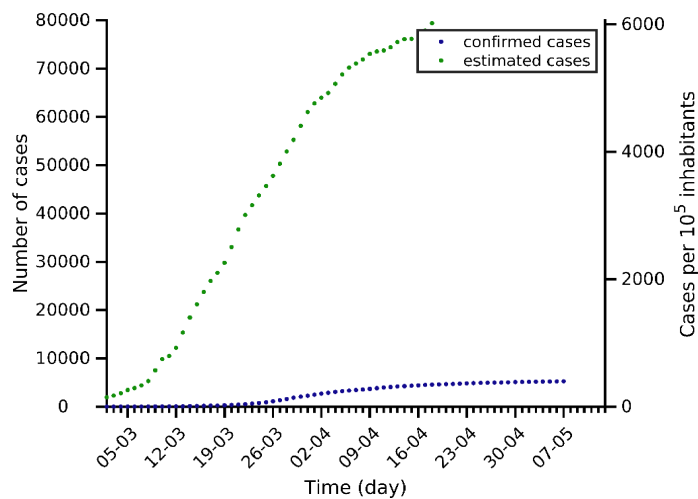
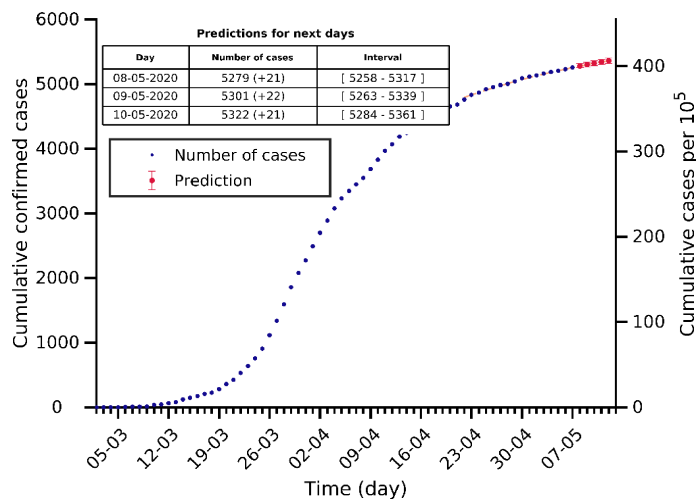
C Valenciana 07-05-2020. Population: 5.0M. Current cumulated incidence: 212/10⁵



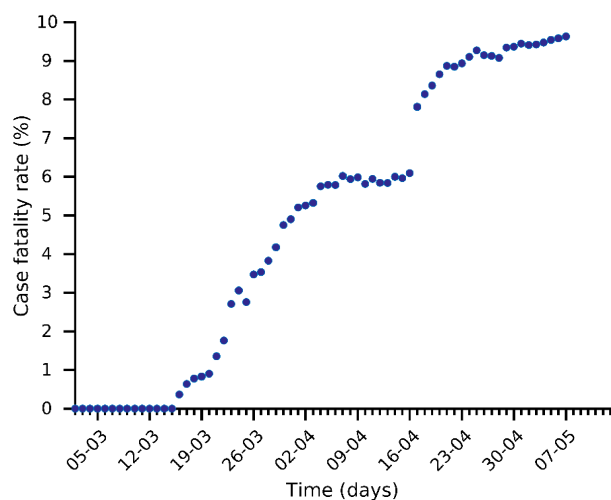
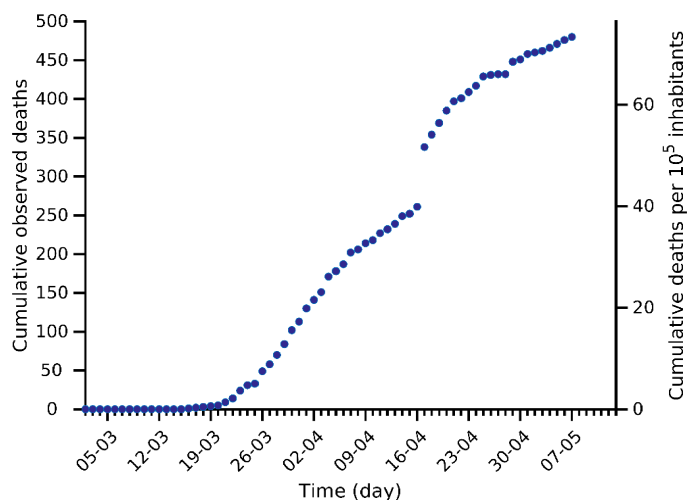
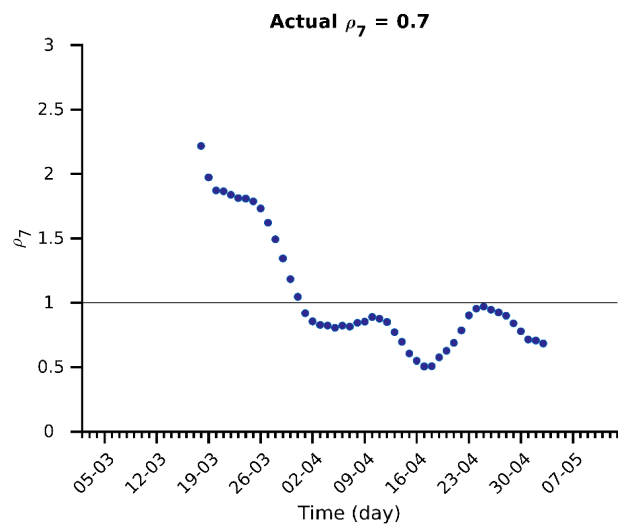
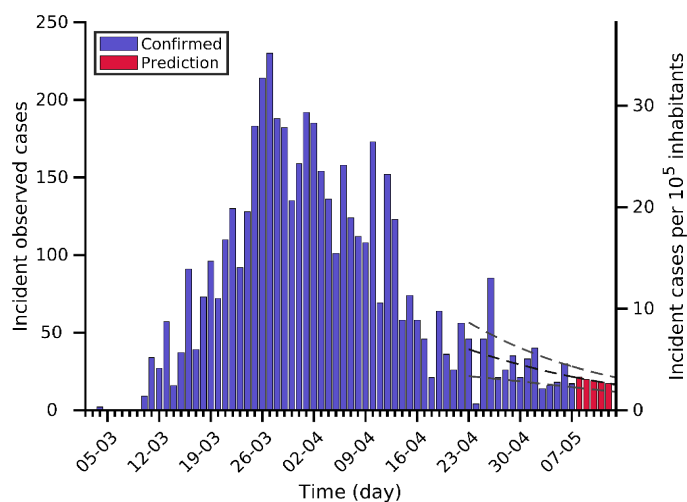
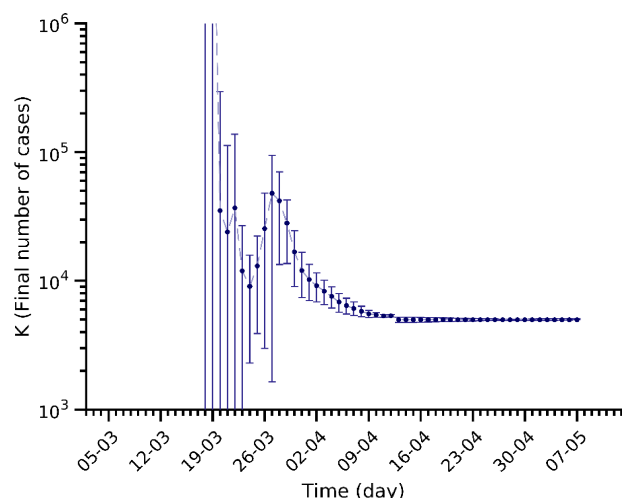
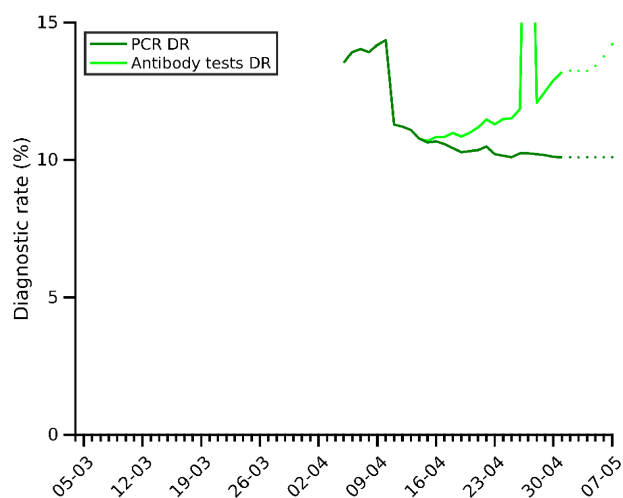
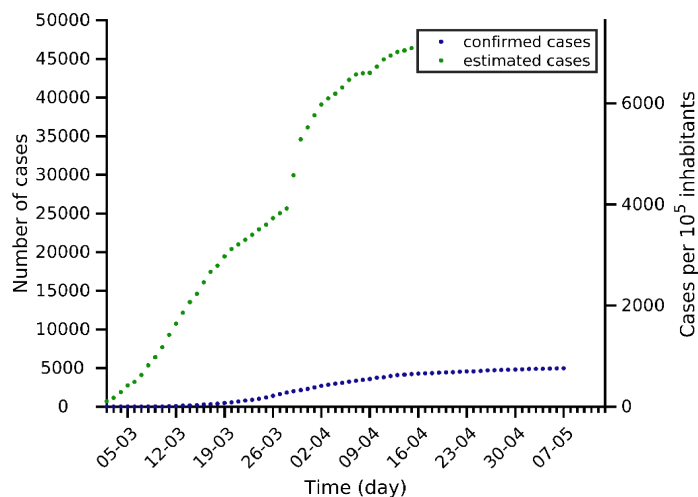
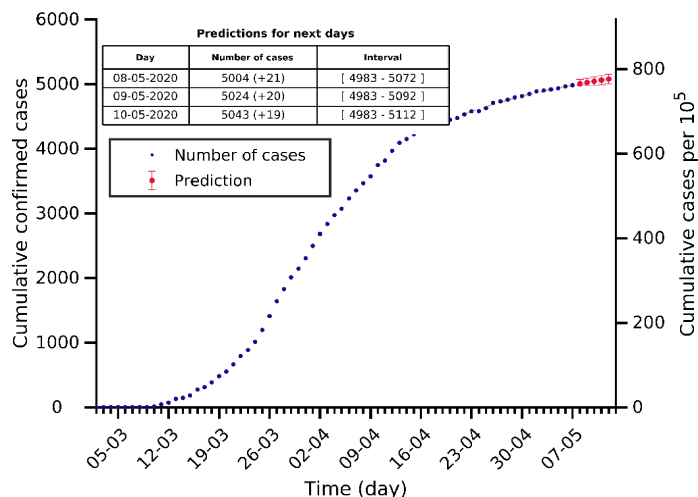
Galicia 07-05-2020. Population: 2.7M. Current cumulated incidence: 338/10⁵



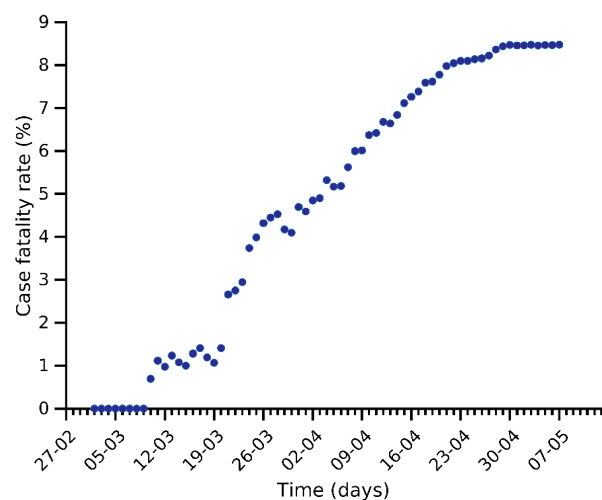
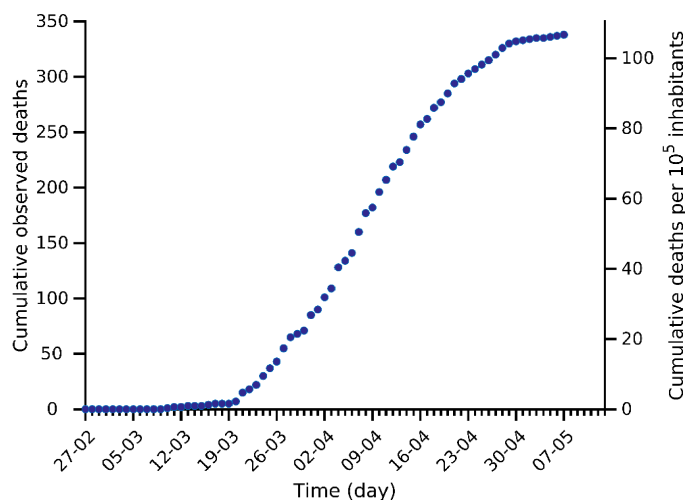
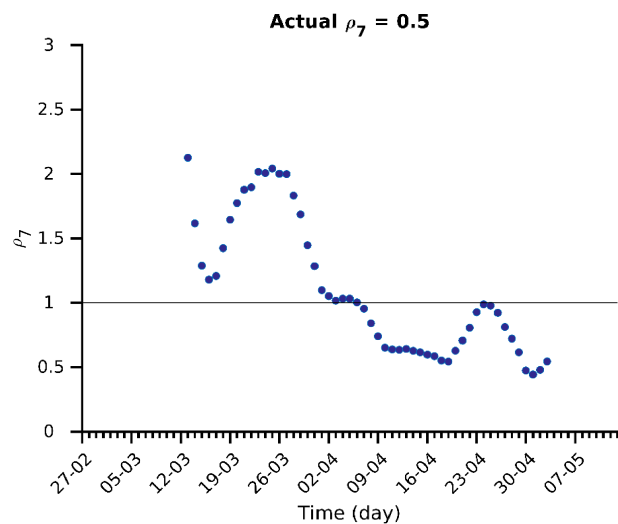
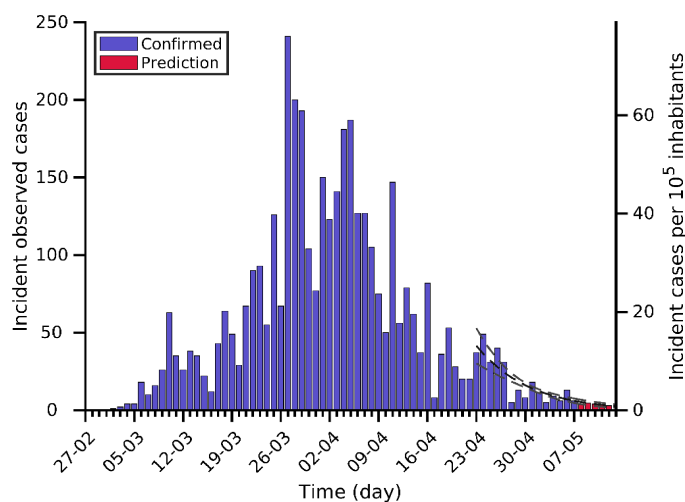
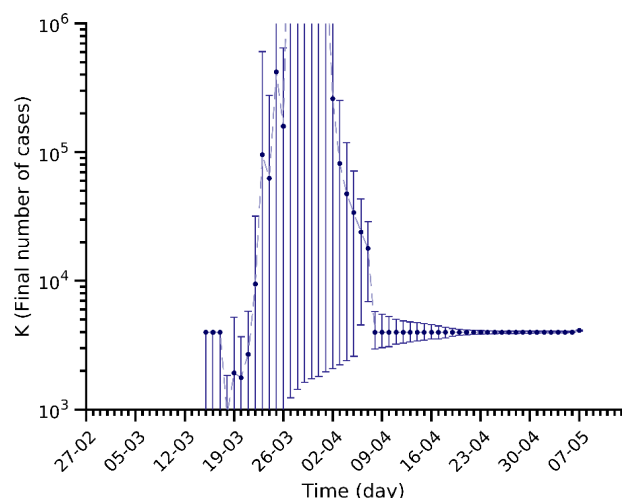
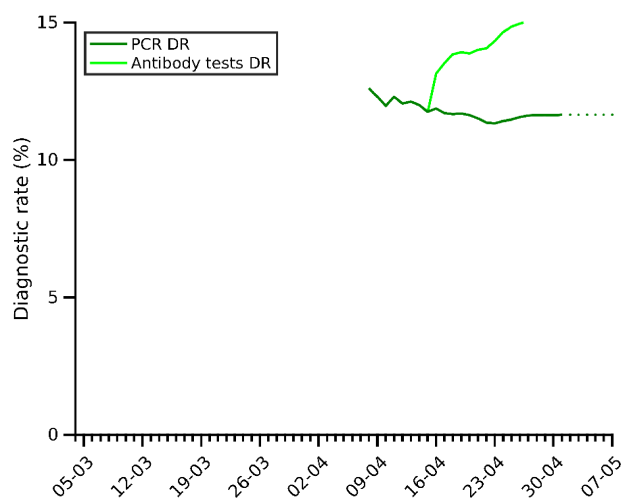
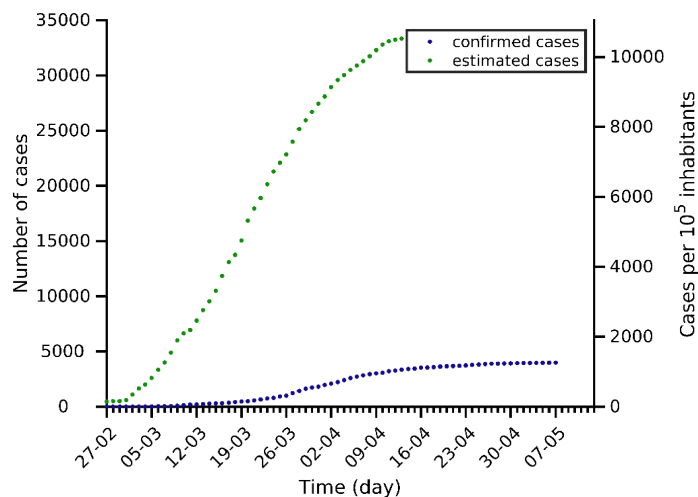
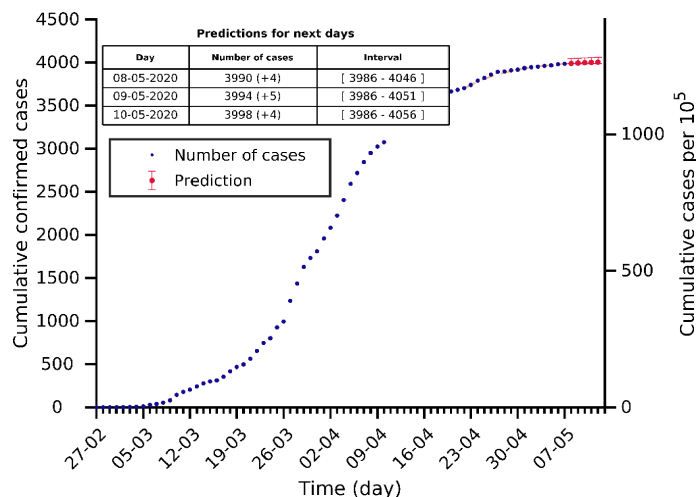
Aragon 07-05-2020. Population: 1.3M. Current cumulated incidence: 399/10⁵



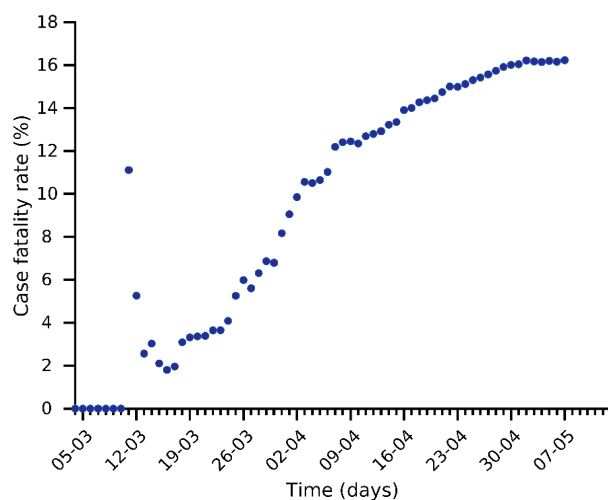
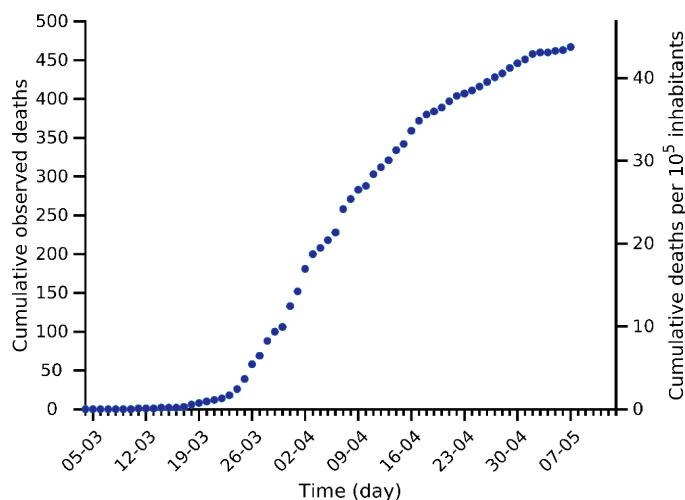
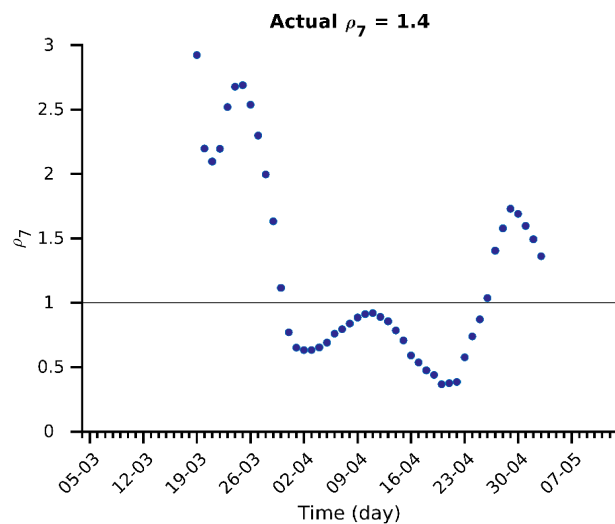
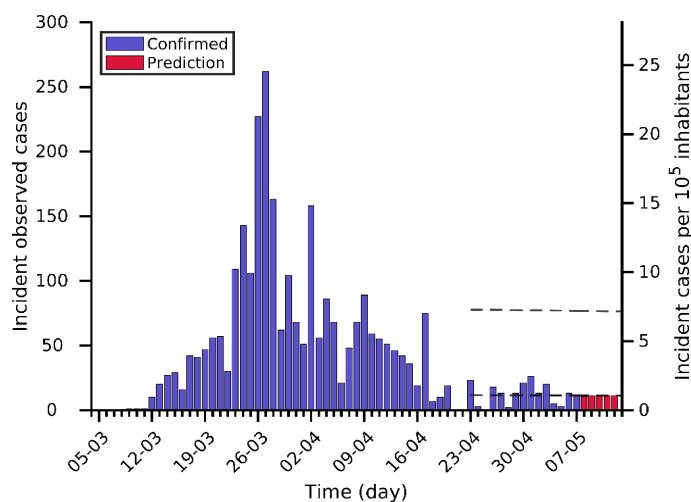
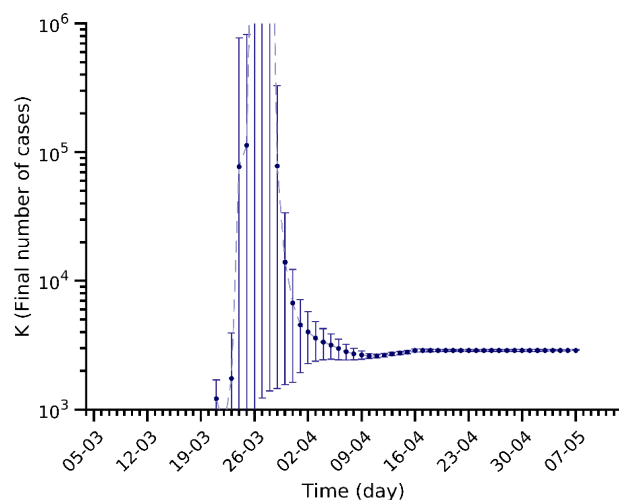
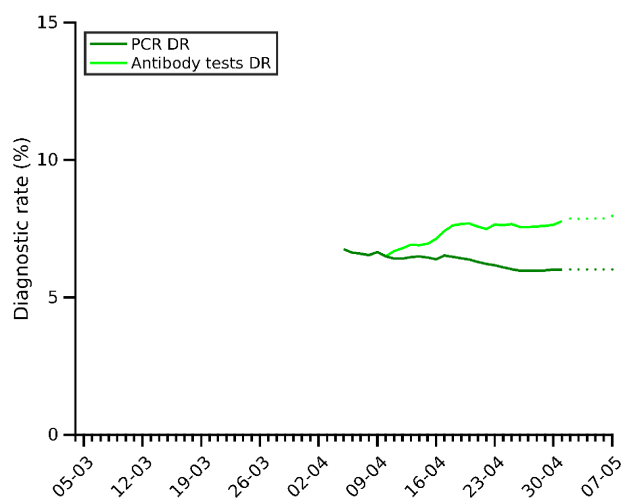
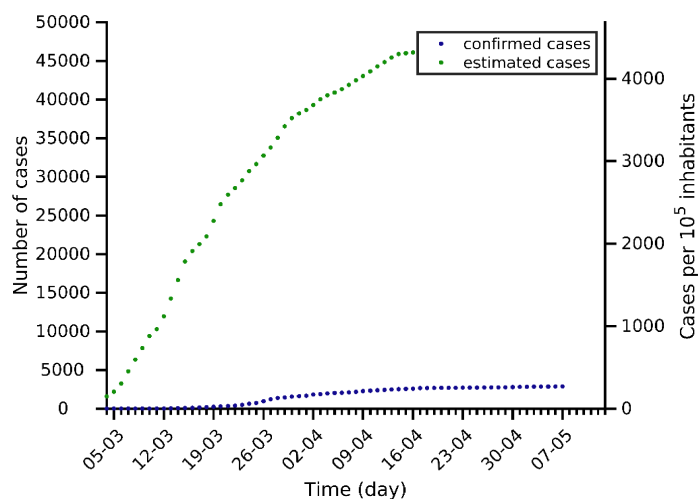
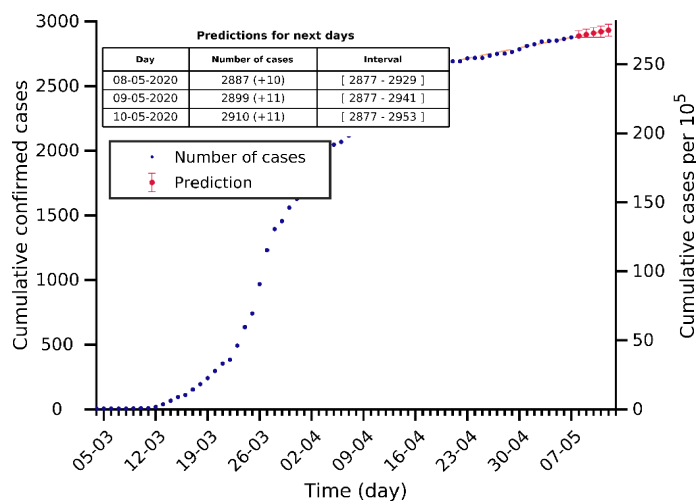
Navarra 07-05-2020. Population: 0.7M. Current cumulated incidence: 762/10⁵



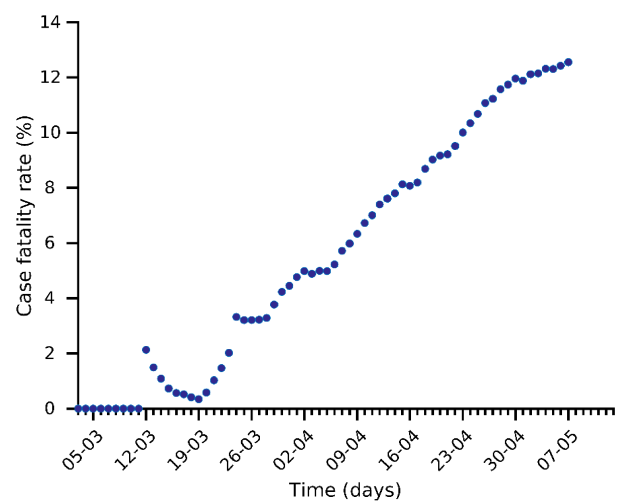
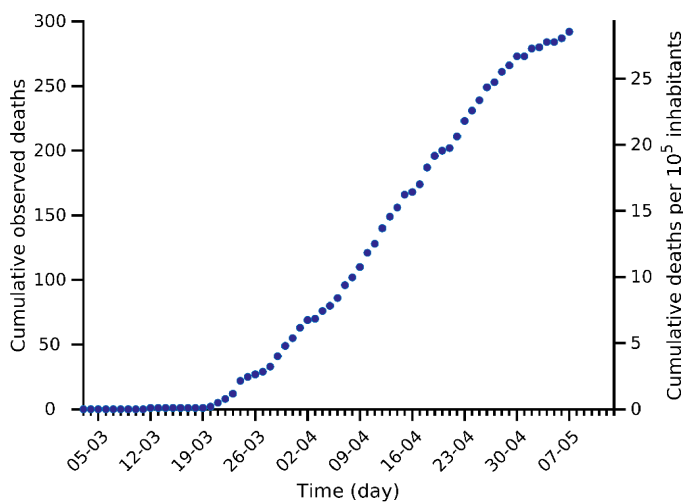
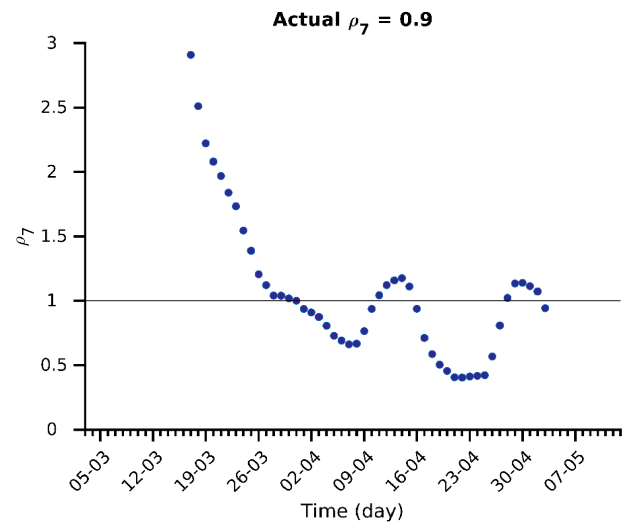
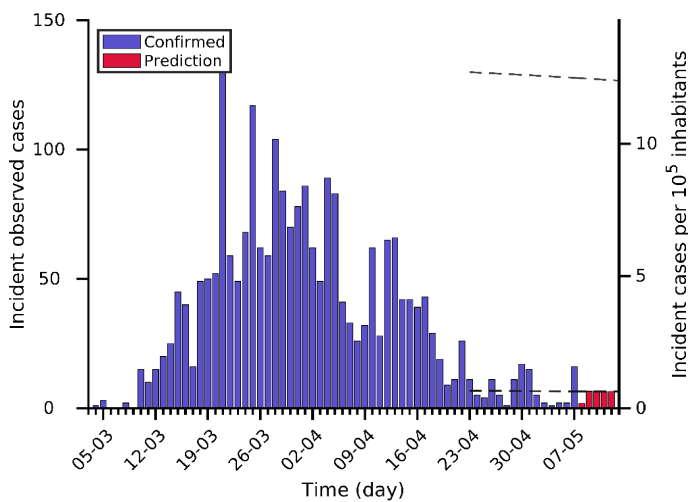
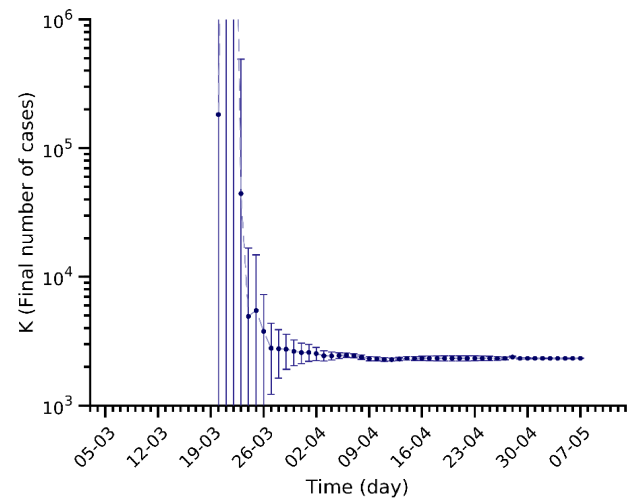
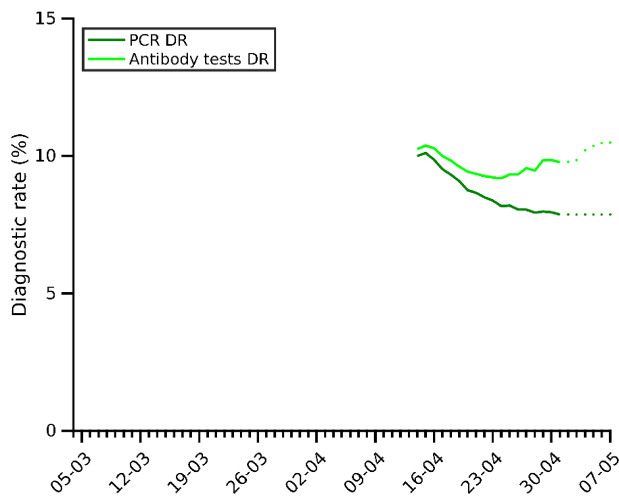
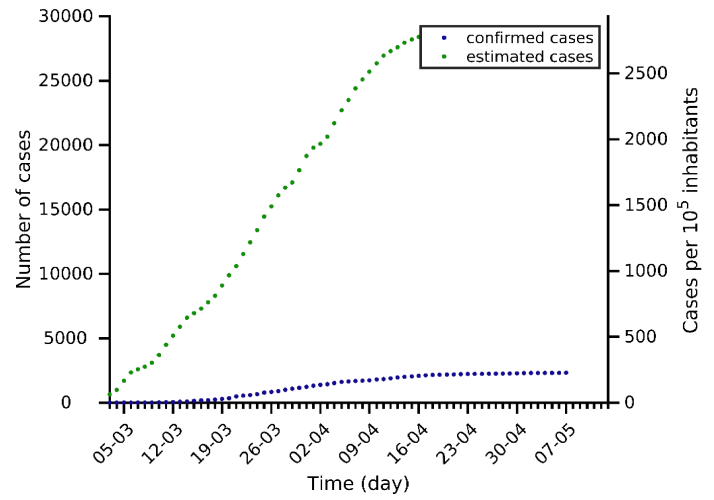
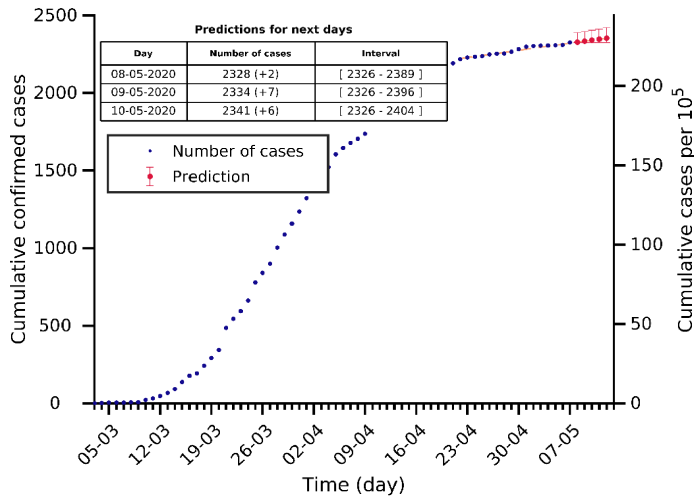
La Rioja 07-05-2020. Population: 0.3M. Current cumulated incidence: 1258/10⁵



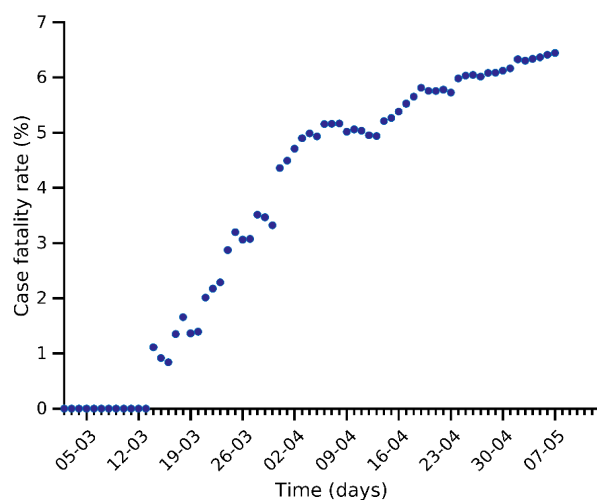
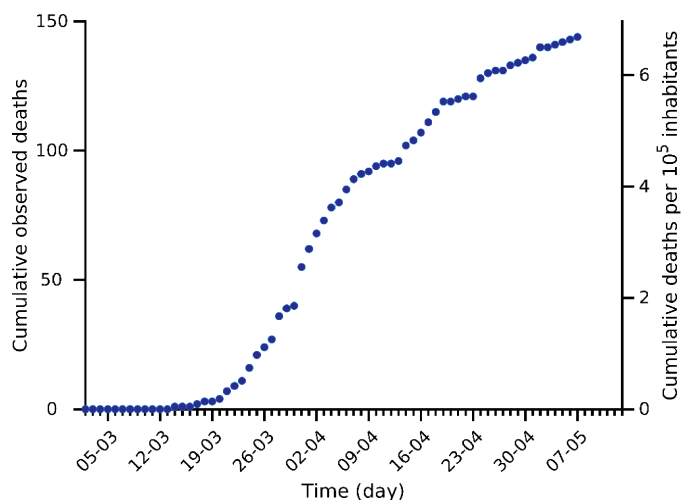
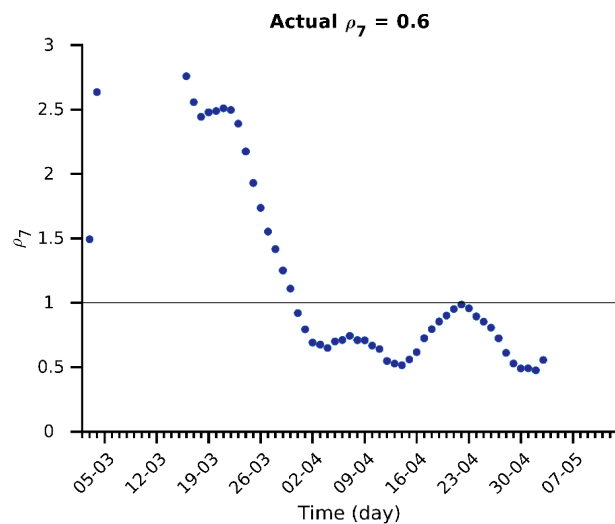
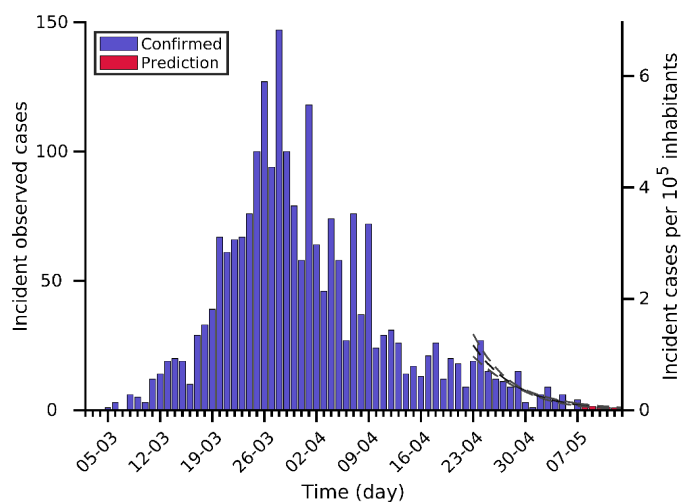
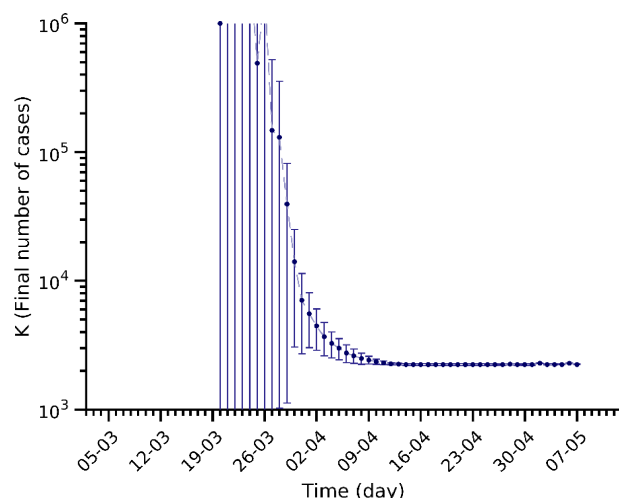
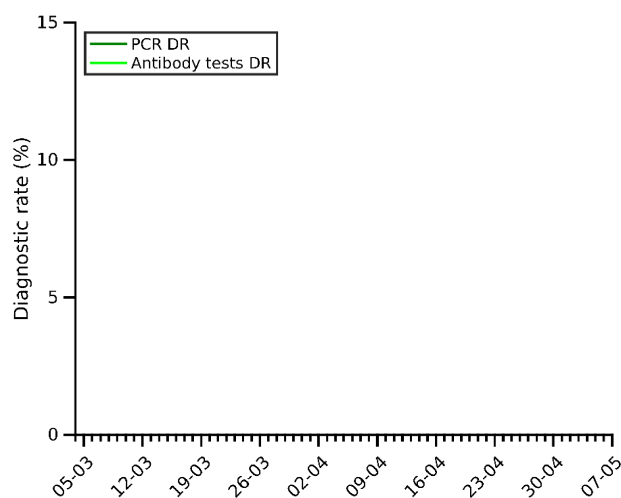
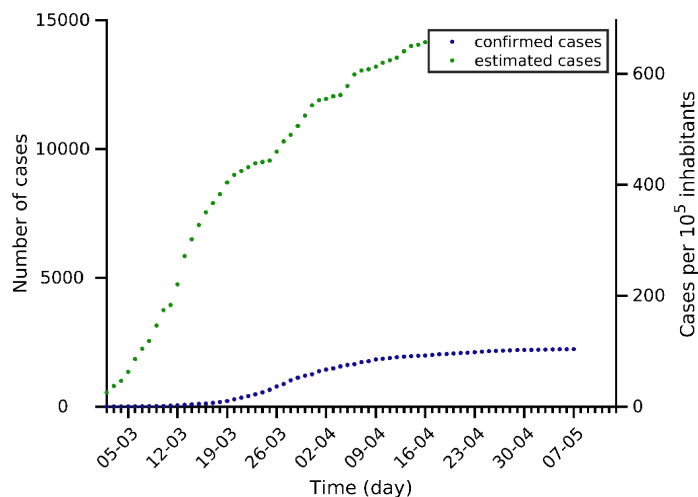
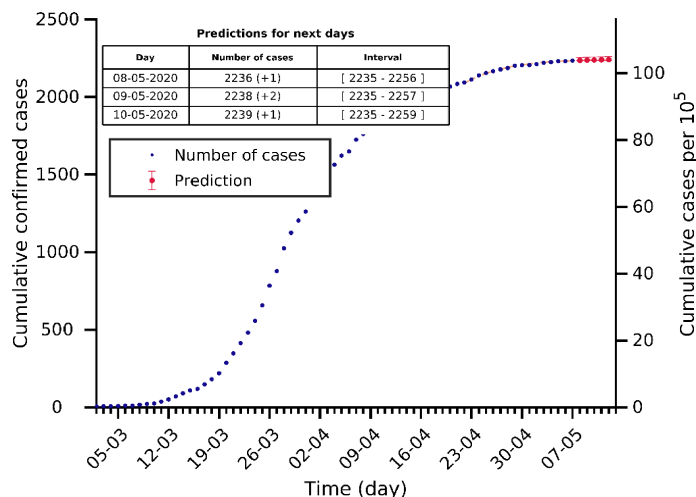
Extremadura 07-05-2020. Population: 1.1M. Current cumulated incidence: 269/10⁵



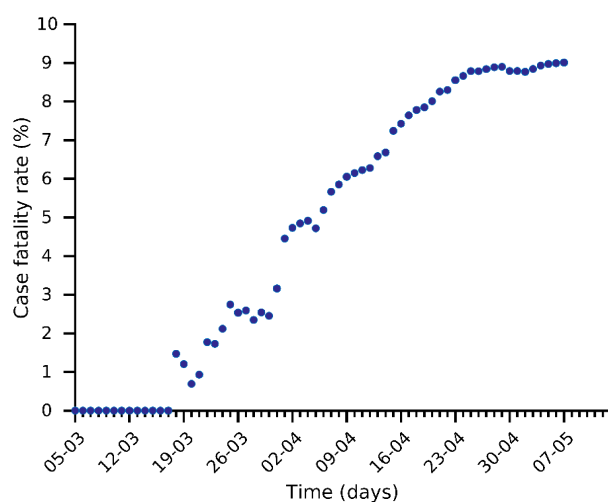
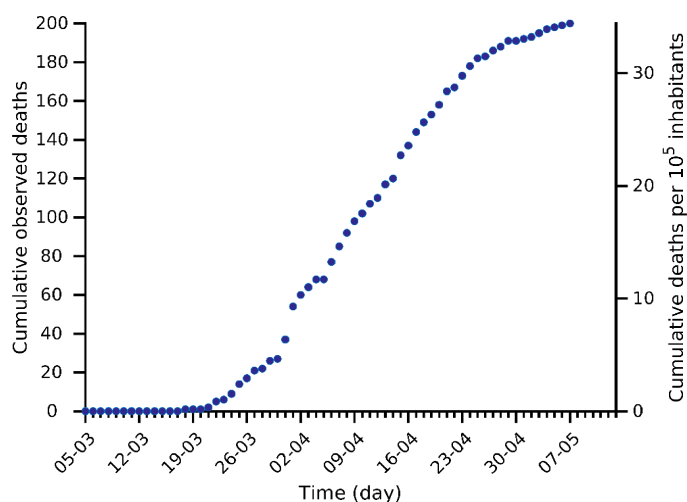
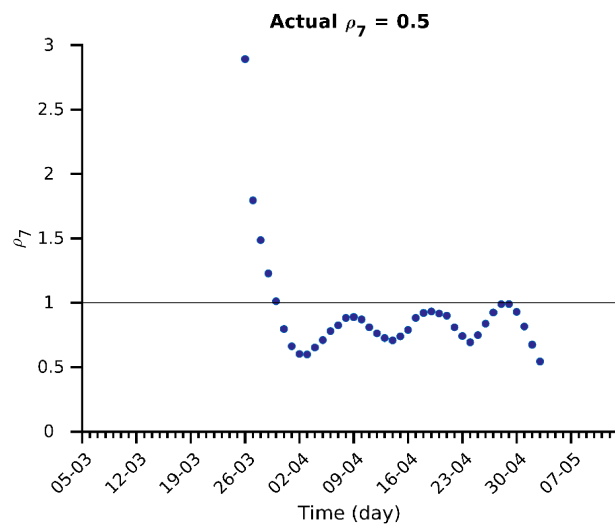
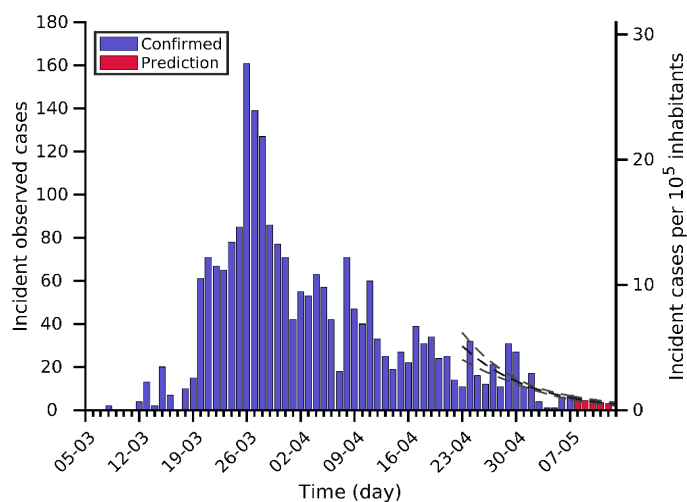
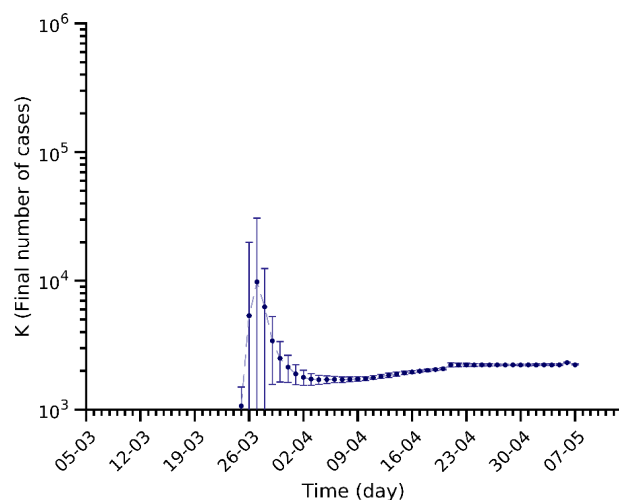
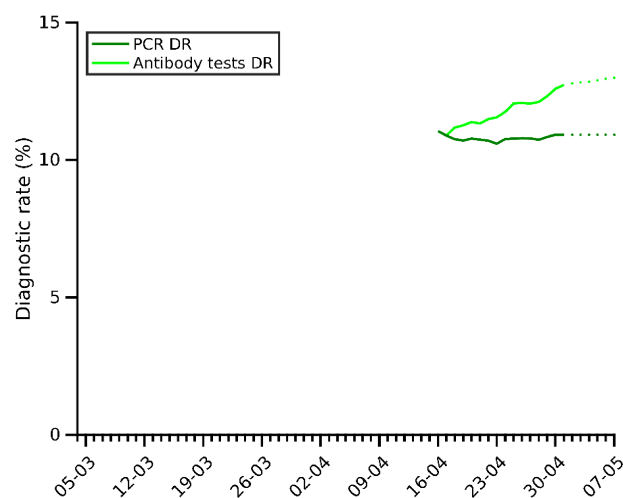
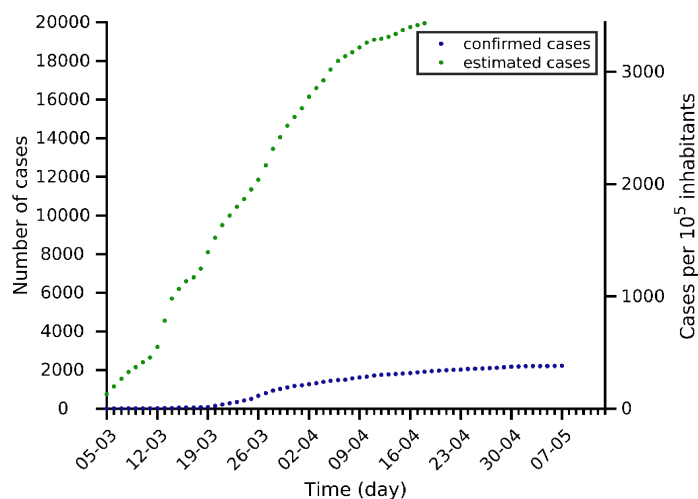
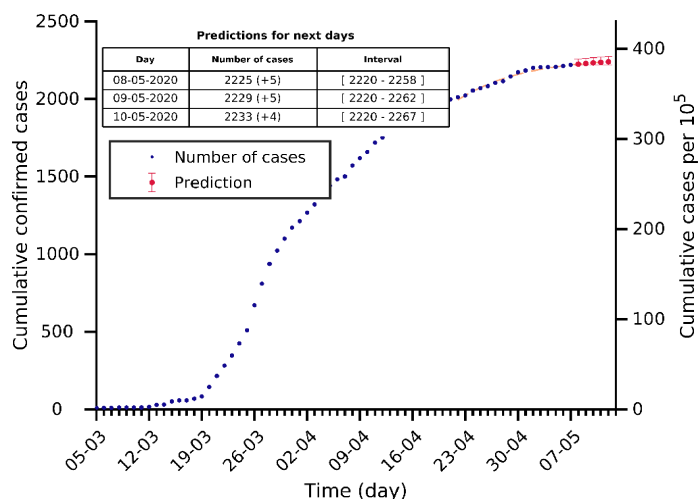
Asturias 07-05-2020. Population: 1.0M. Current cumulated incidence: 227/10⁵



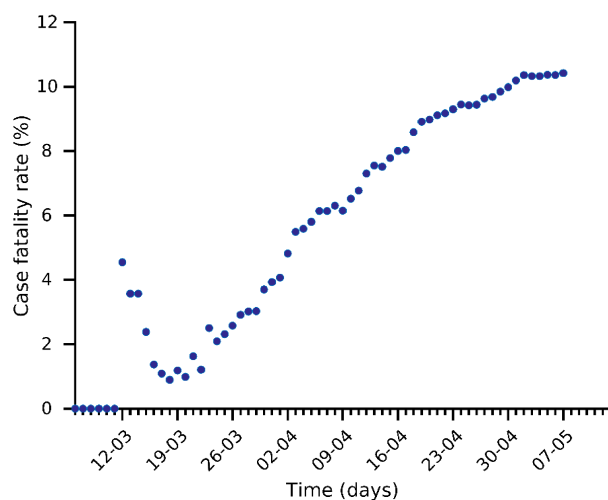
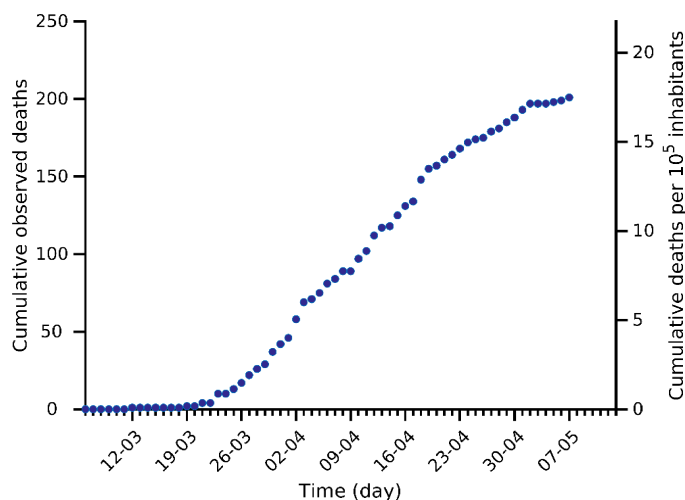
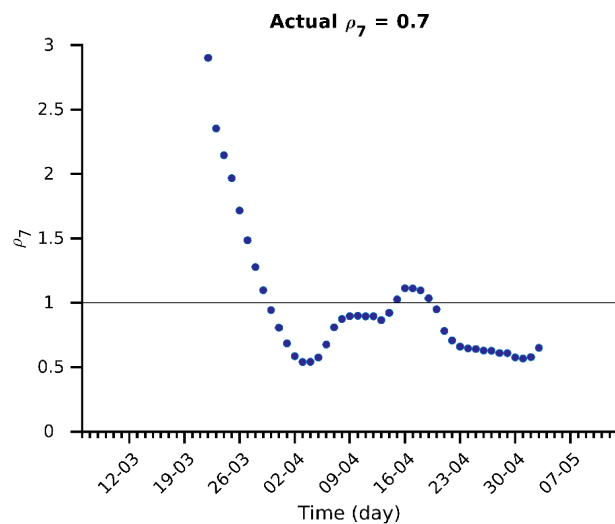
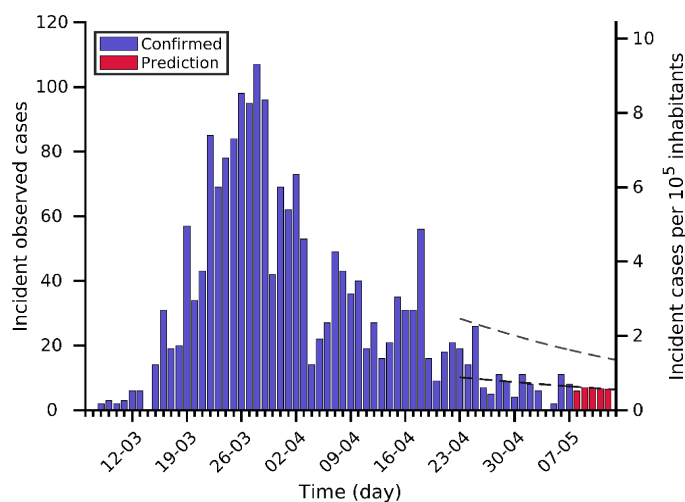
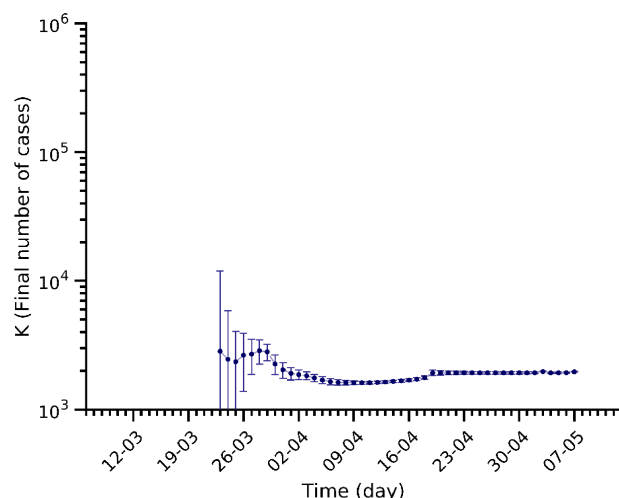
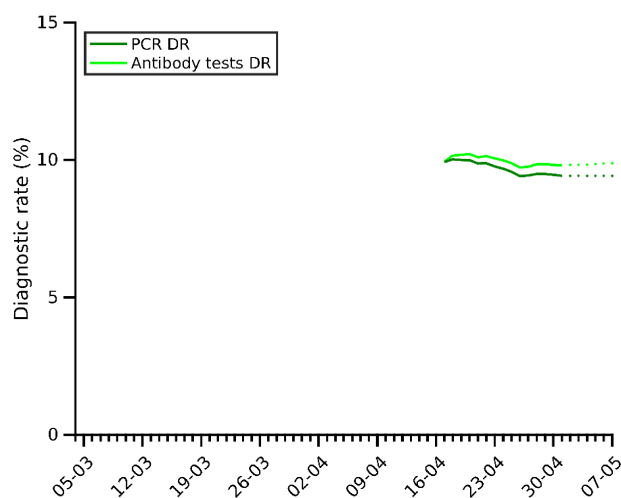
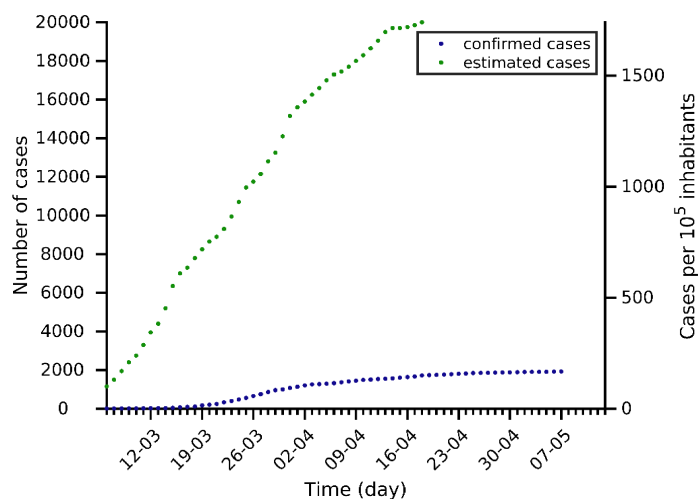
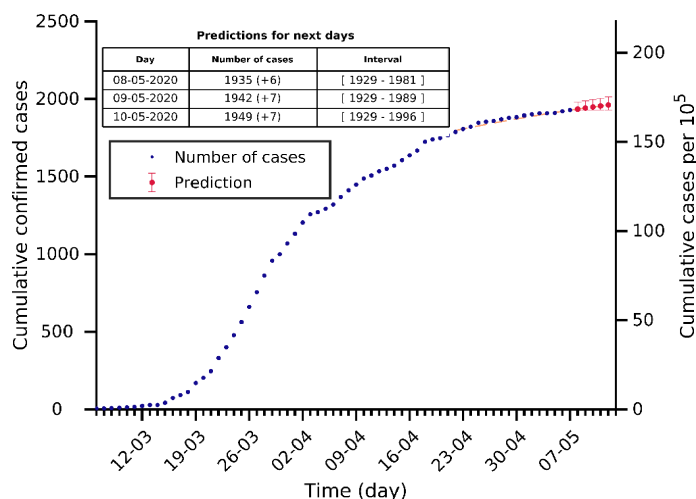
Canarias 07-05-2020. Population: 2.2M. Current cumulated incidence: 104/10⁵



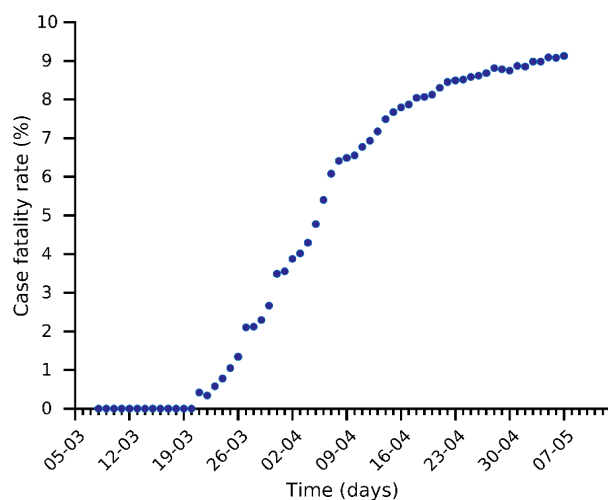
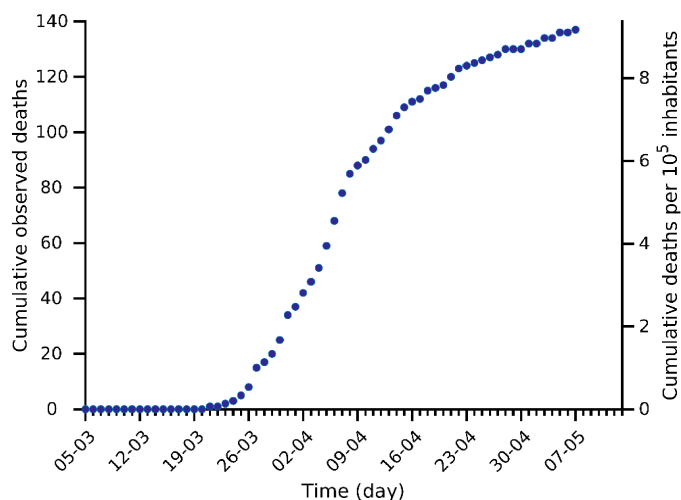
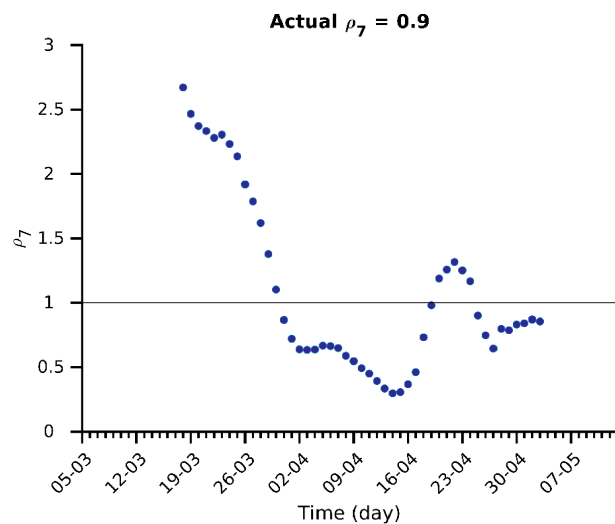
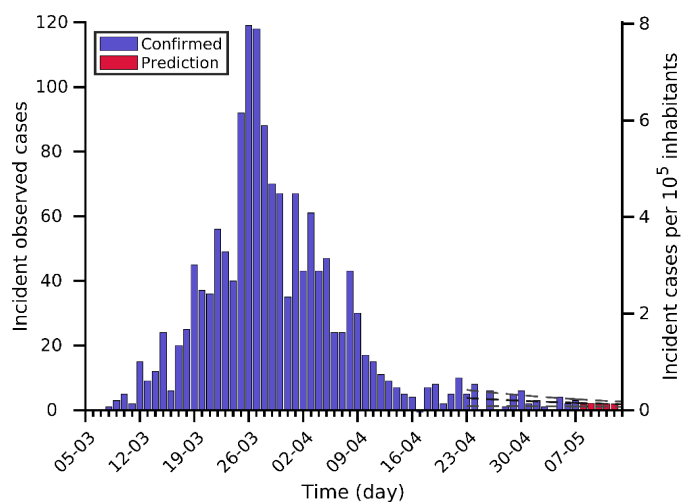
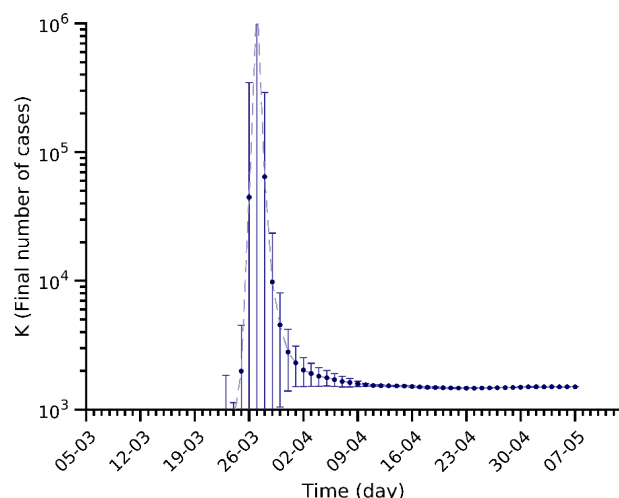
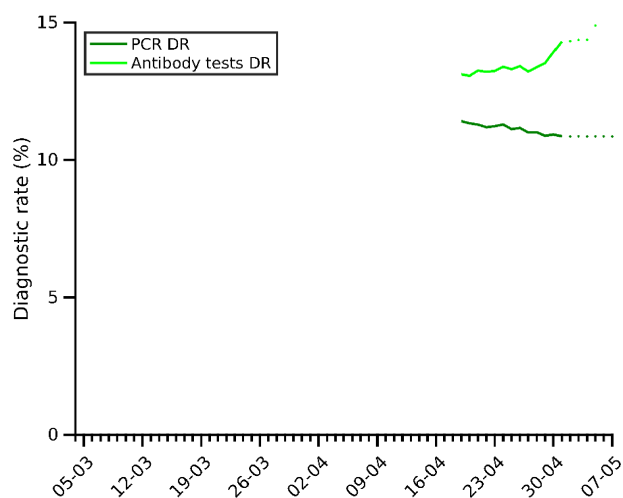
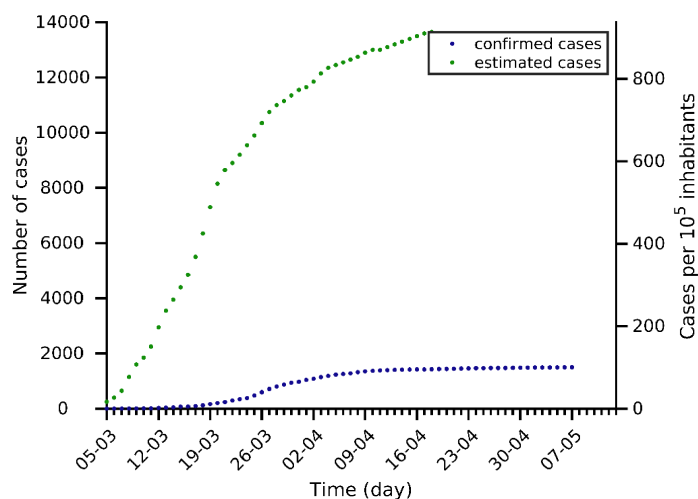
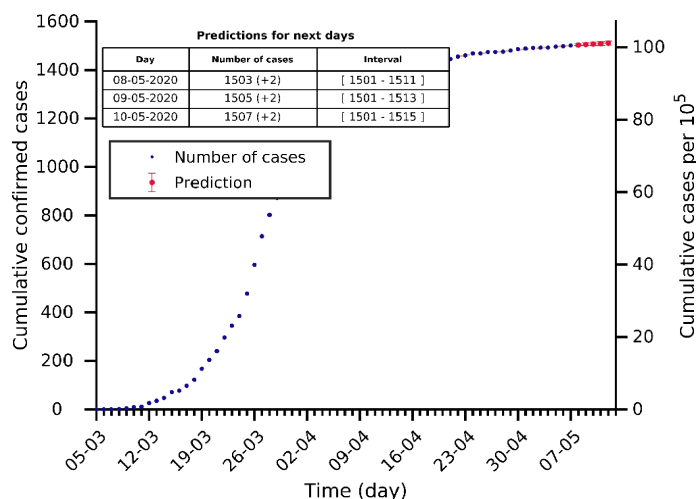
Cantabria 07-05-2020. Population: 0.6M. Current cumulated incidence: 382/10⁵



Baleares 07-05-2020. Population: 1.1M. Current cumulated incidence: 168/10⁵



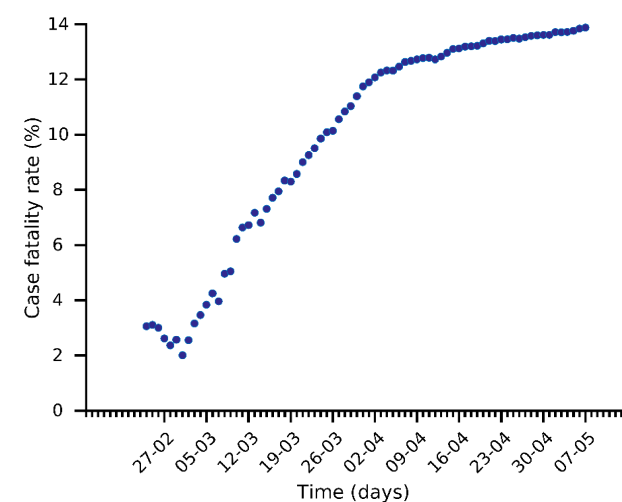
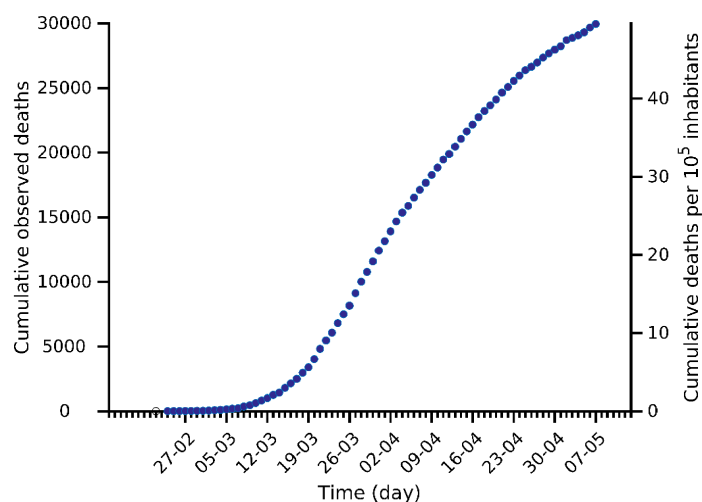
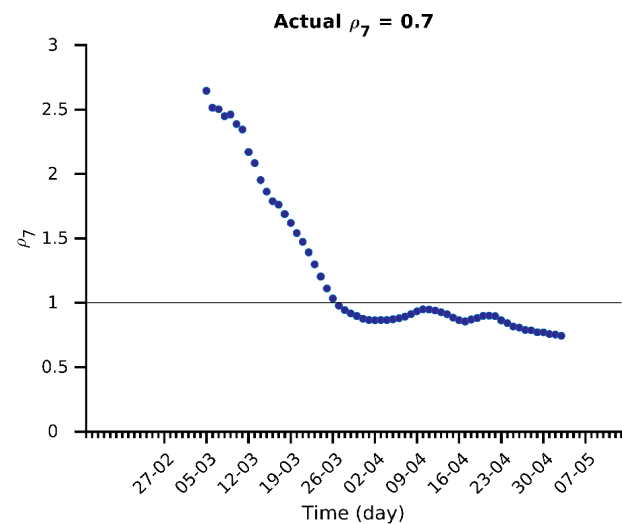
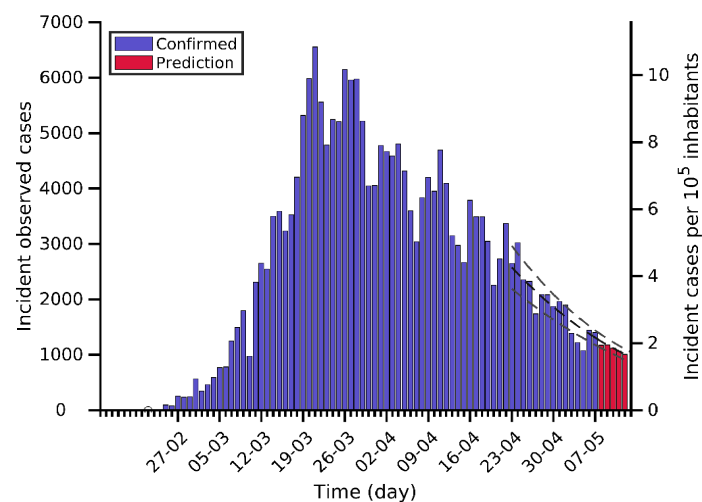
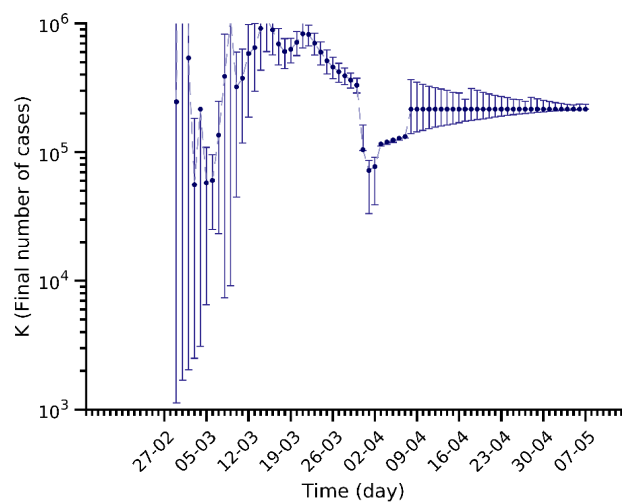
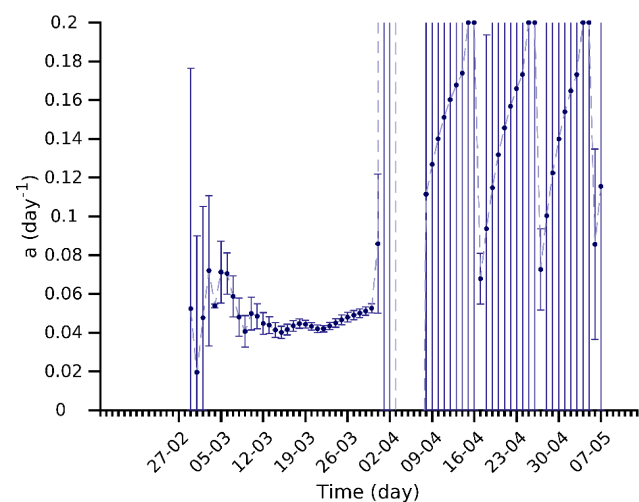
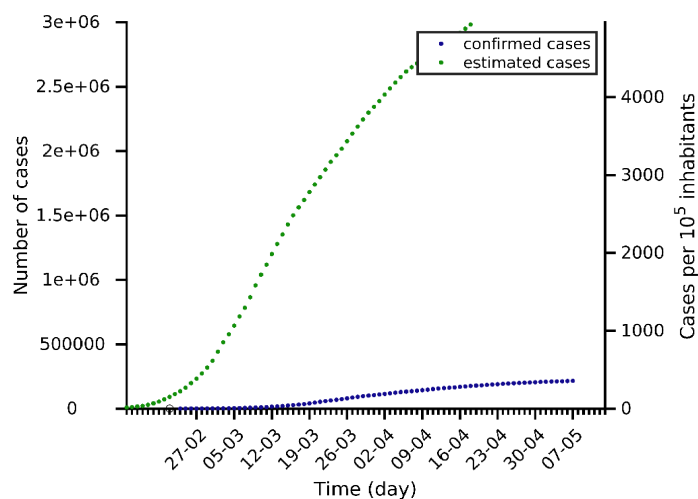
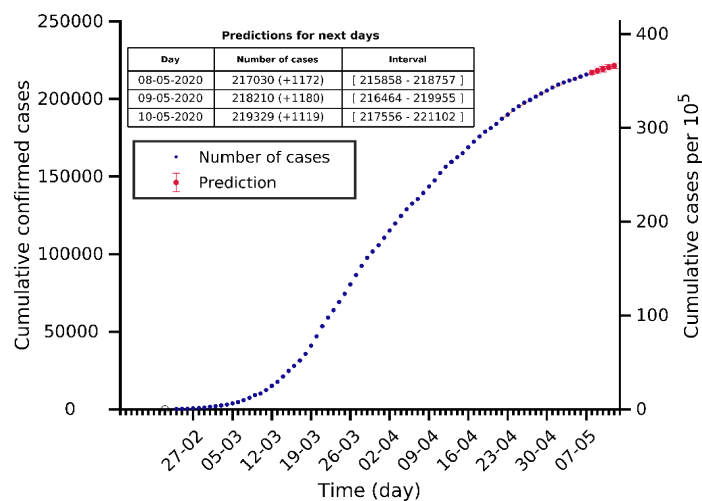
Murcia 07-05-2020. Population: 1.5M. Current cumulated incidence: 100/10⁵



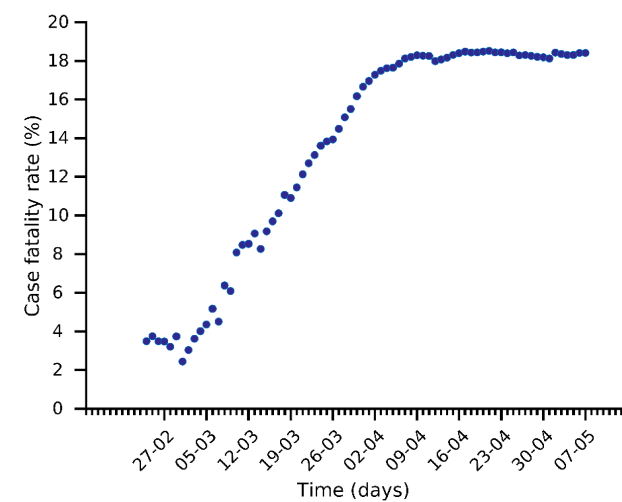
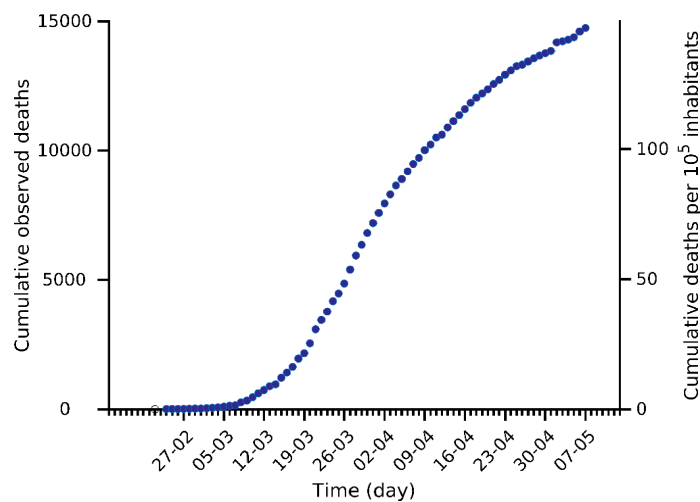
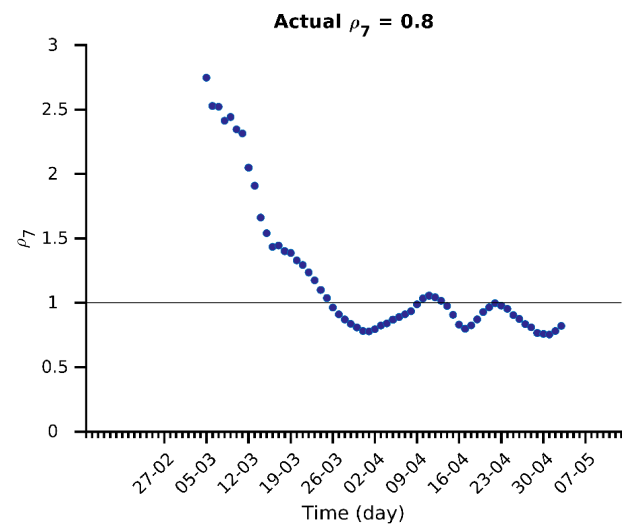
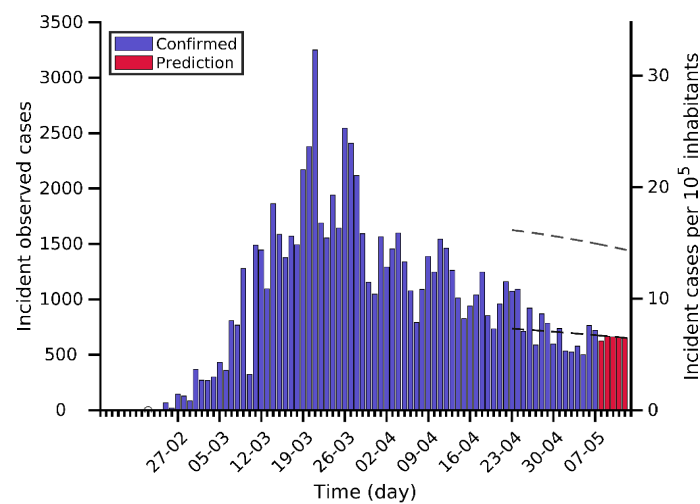
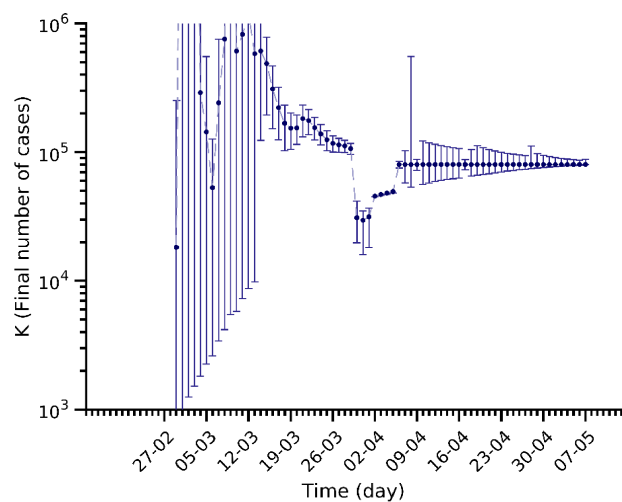
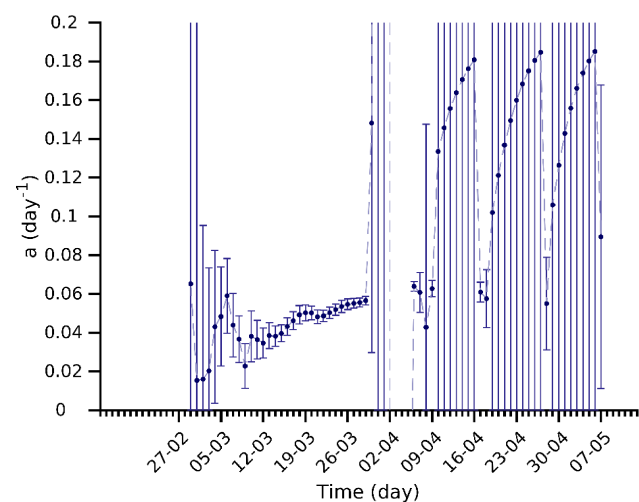
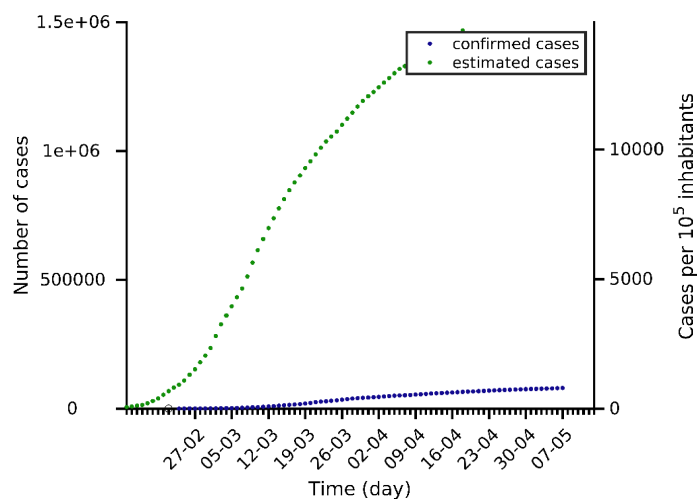
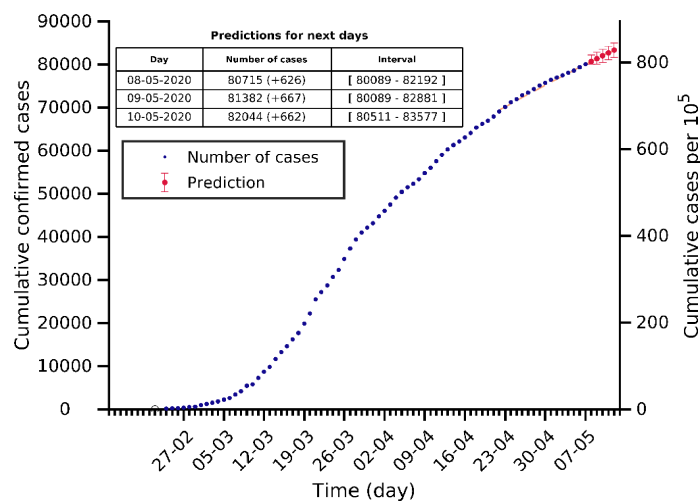
(4) Analysis and prediction of COVID-19 for Italy and its regions

Data obtained from: <https://github.com/pcm-dpc/COVID-19/tree/master/dati-andamento-nazionale>

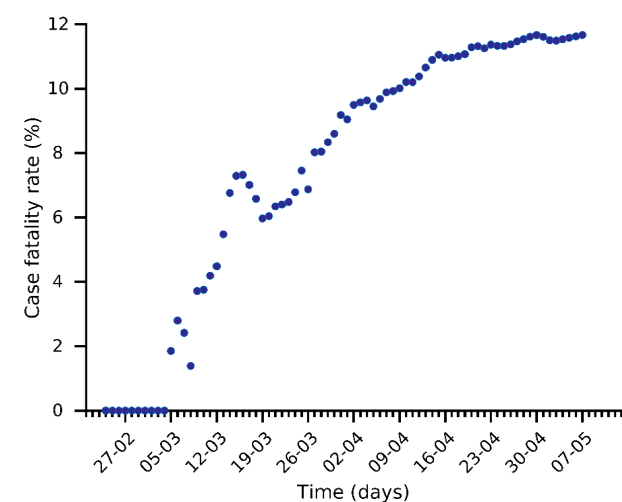
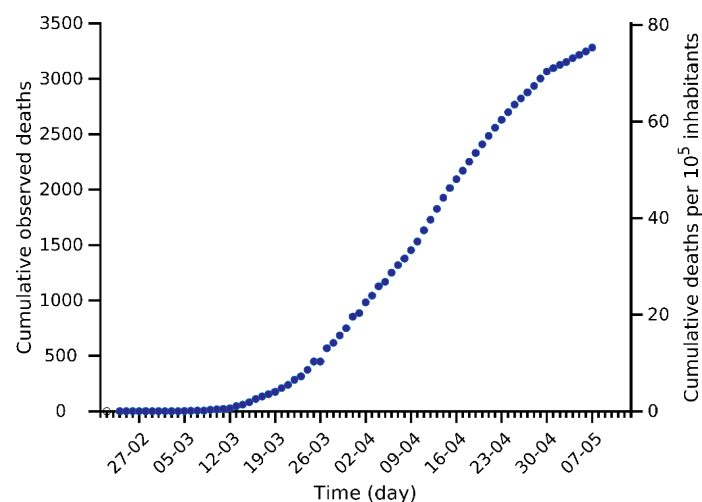
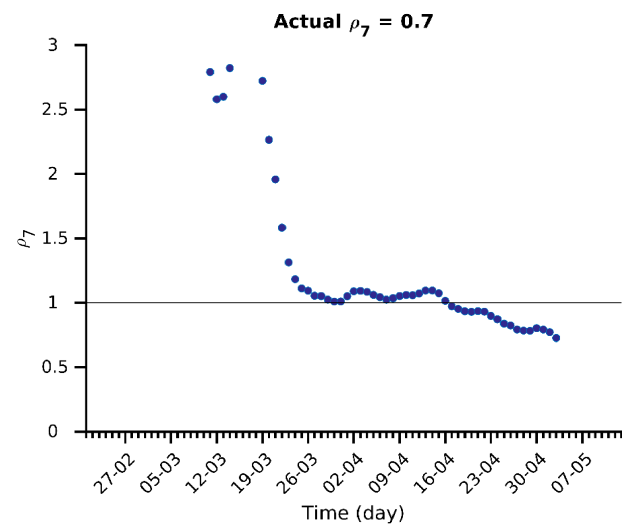
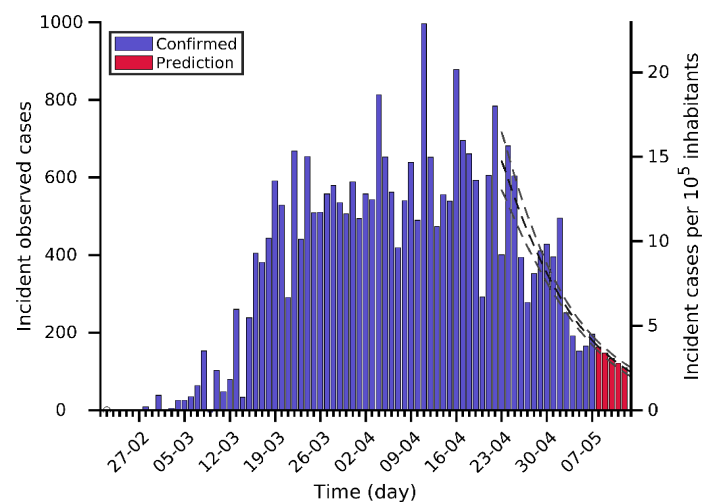
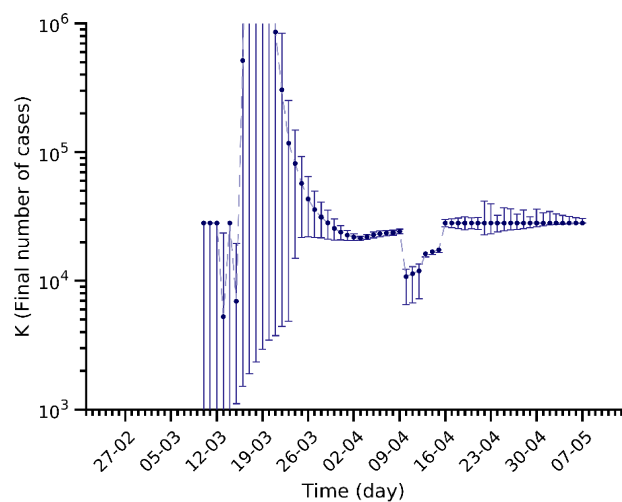
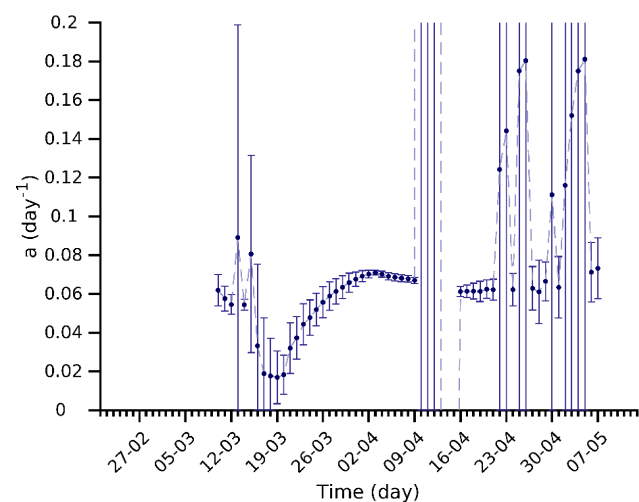
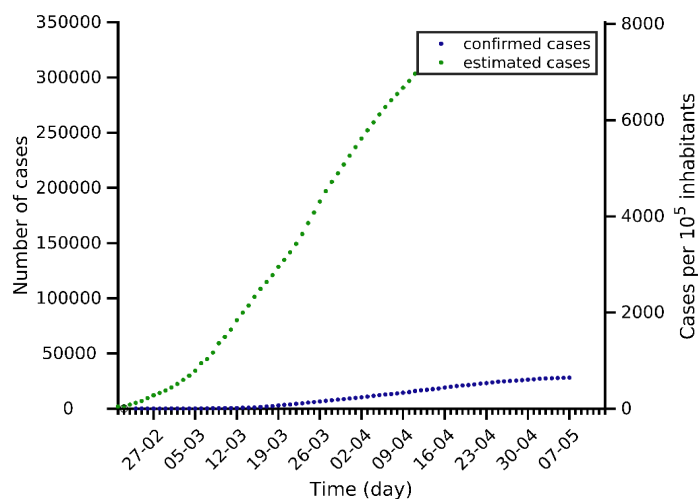
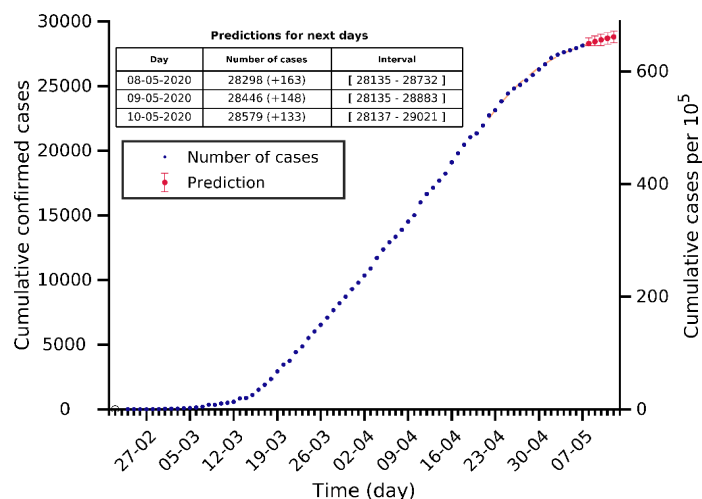
Italy 07-05-2020. Population: 60.5M. Current cumulated incidence: 357/10⁵



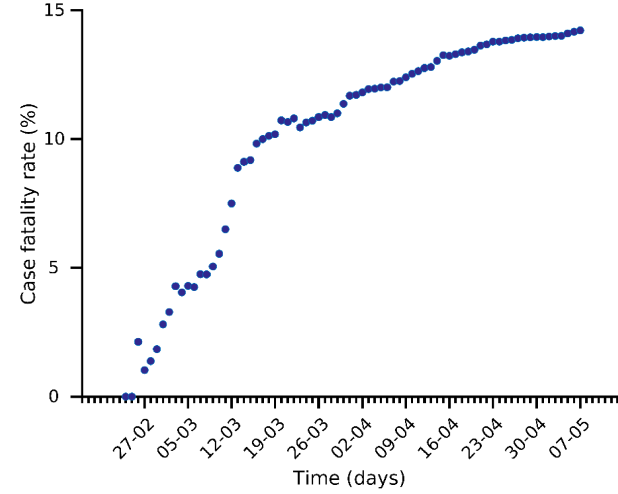
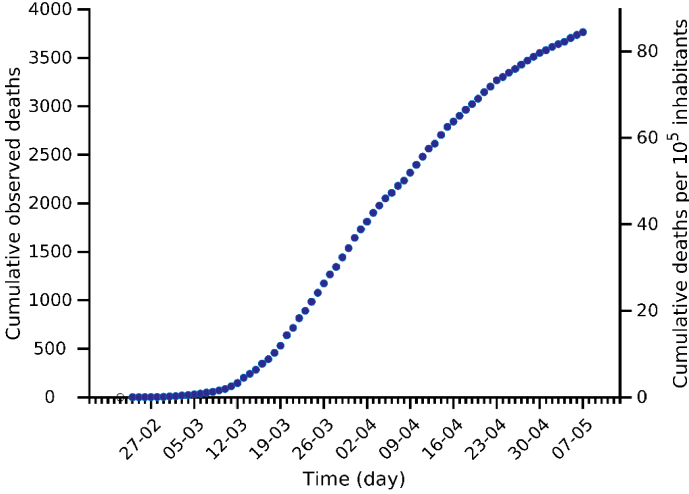
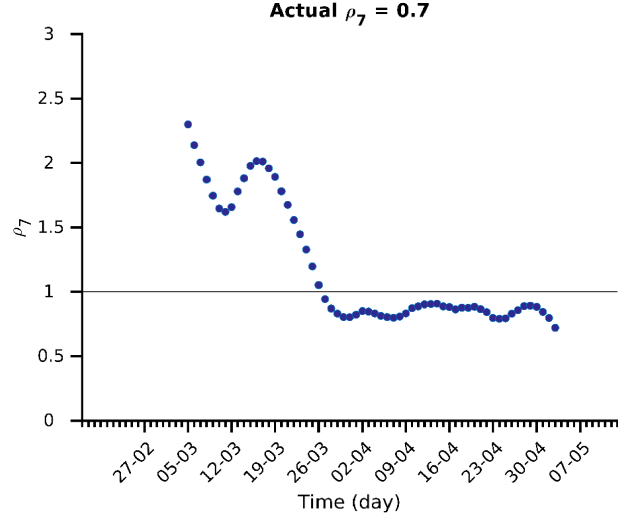
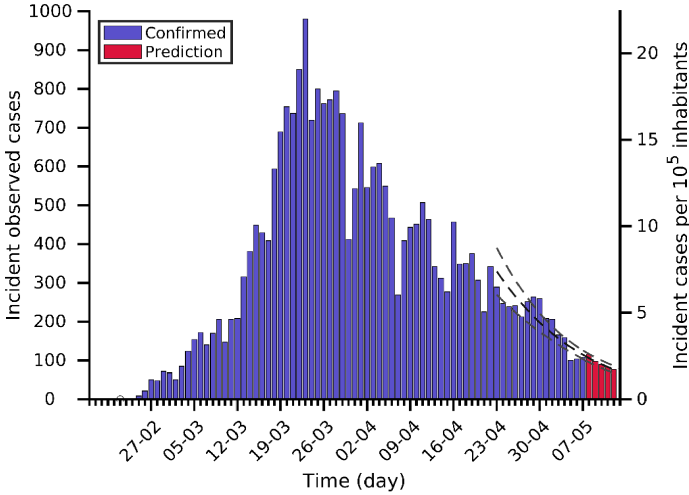
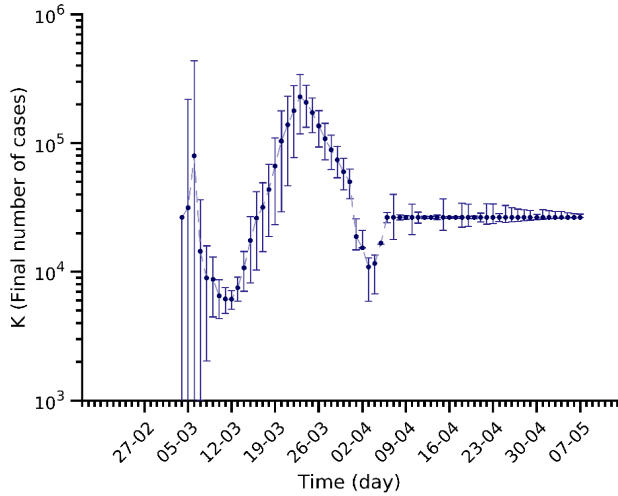
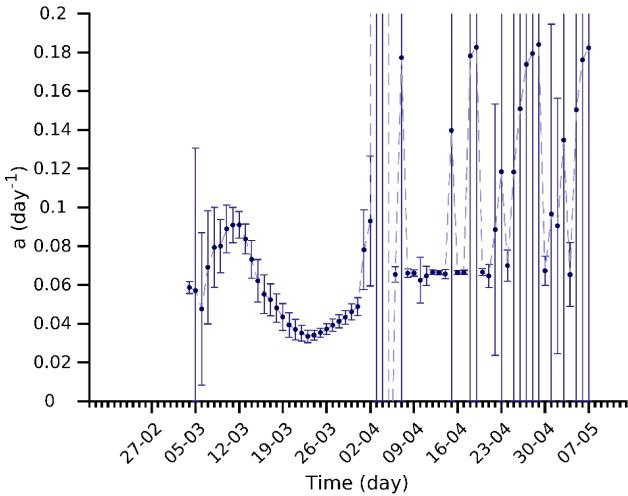
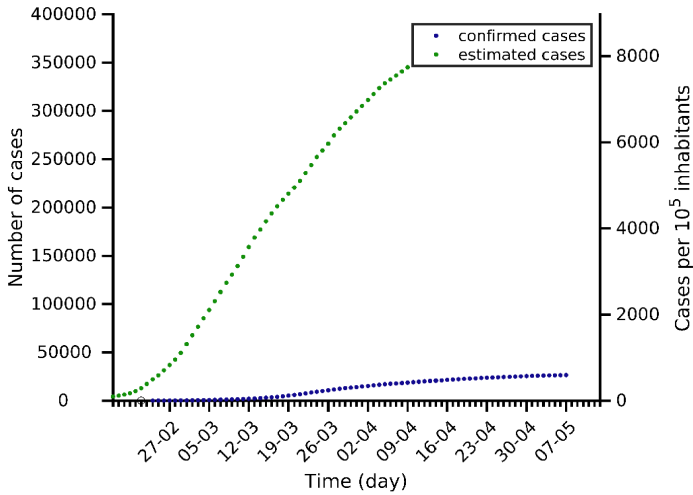
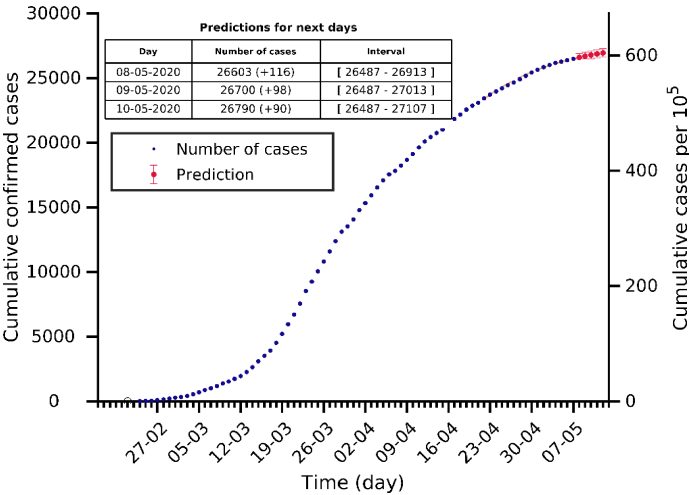
Lombardia 07-05-2020. Population: 10.1M. Current cumulated incidence: 796/10⁵



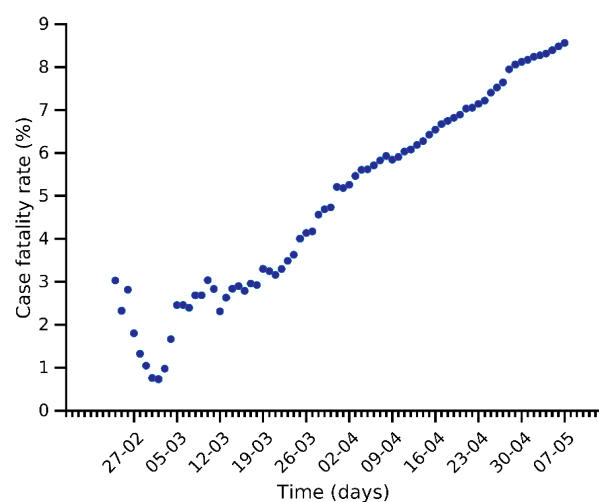
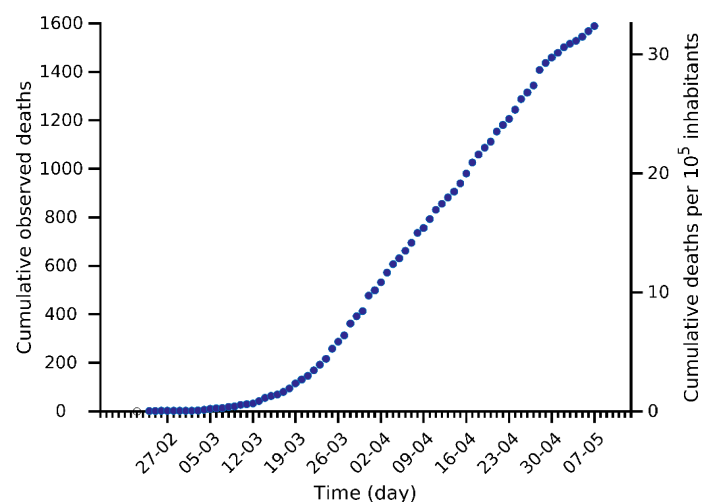
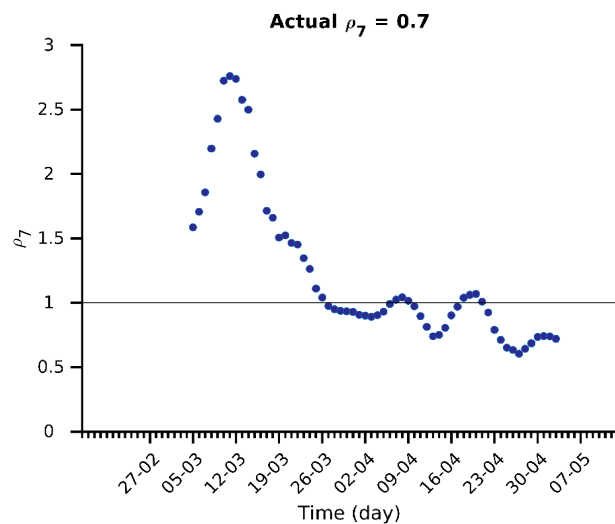
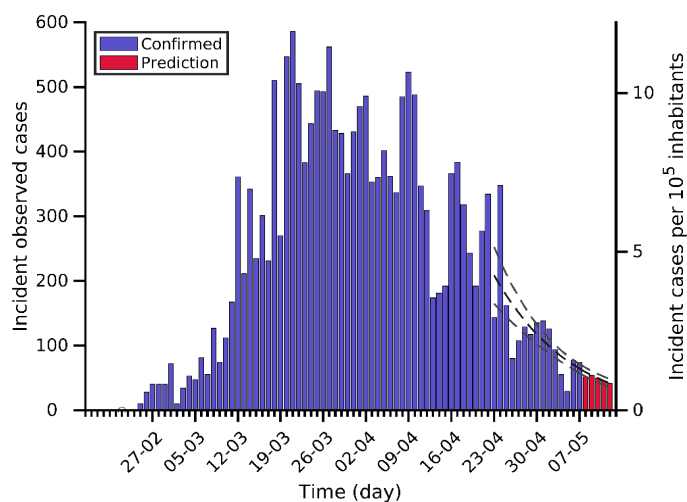
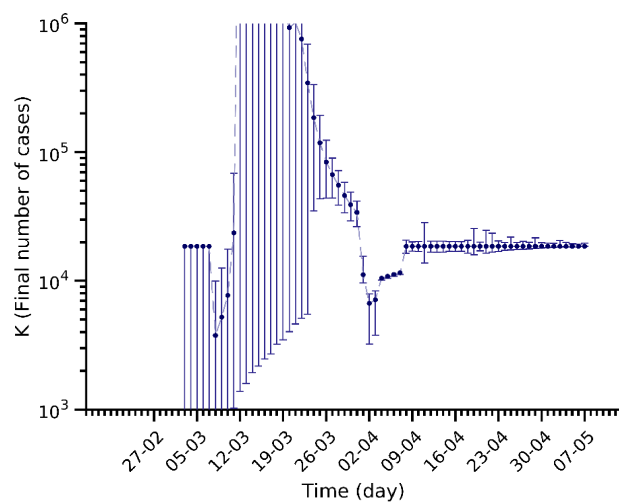
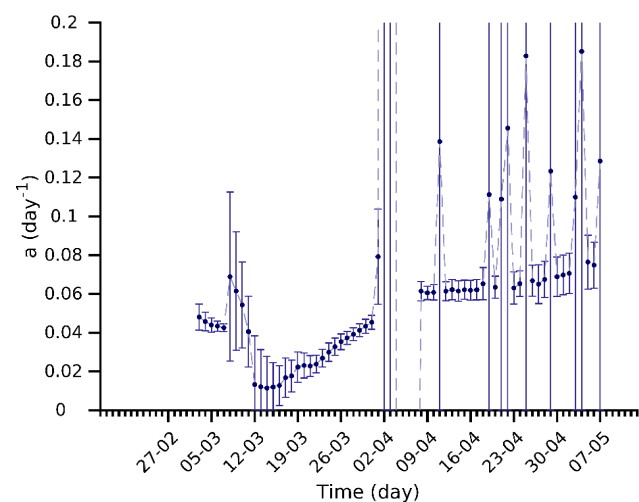
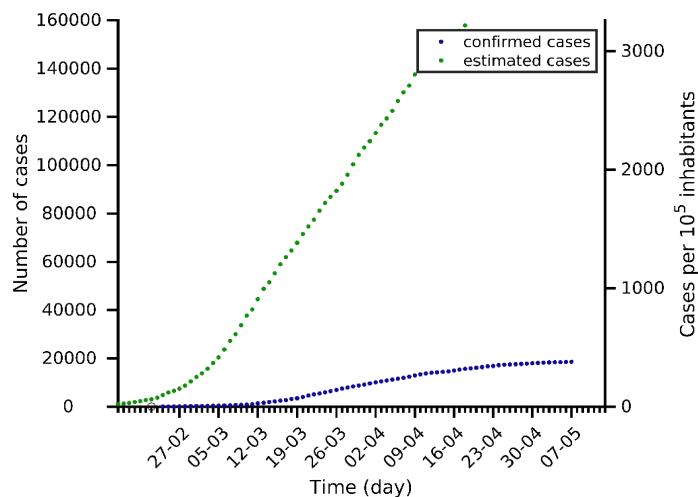
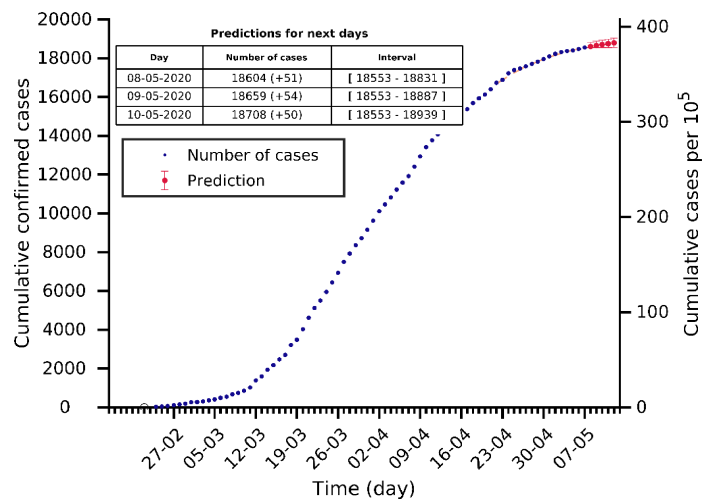
Piemonte 07-05-2020. Population: 4.4M. Current cumulated incidence: 646/10⁵



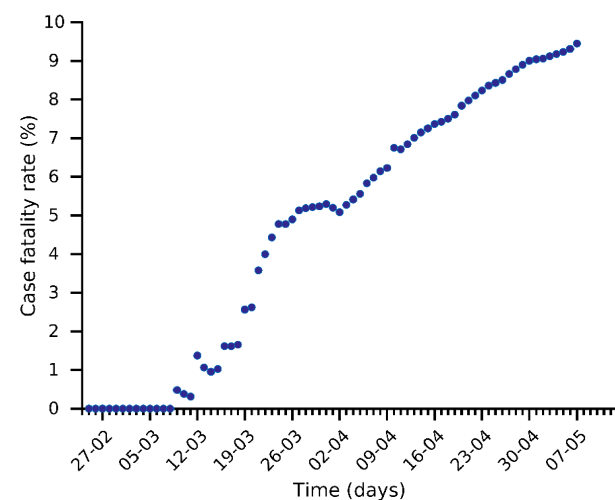
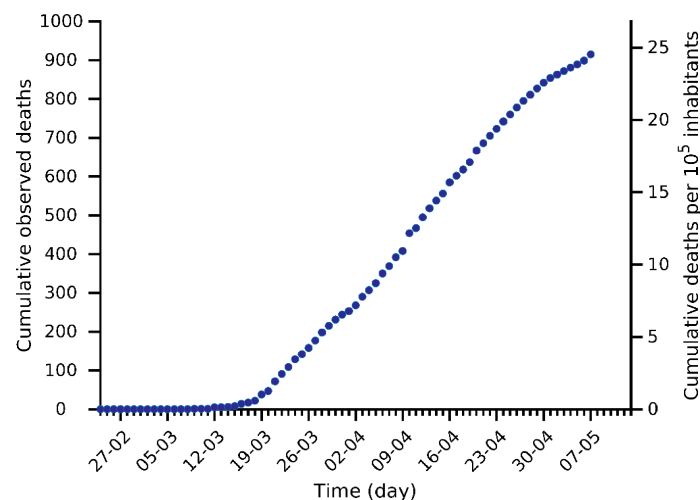
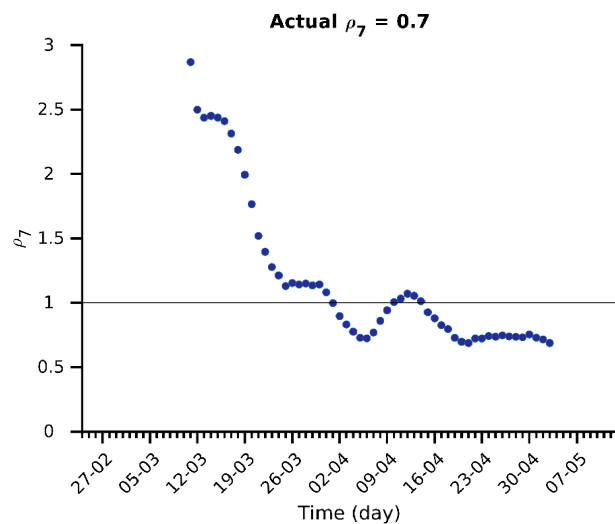
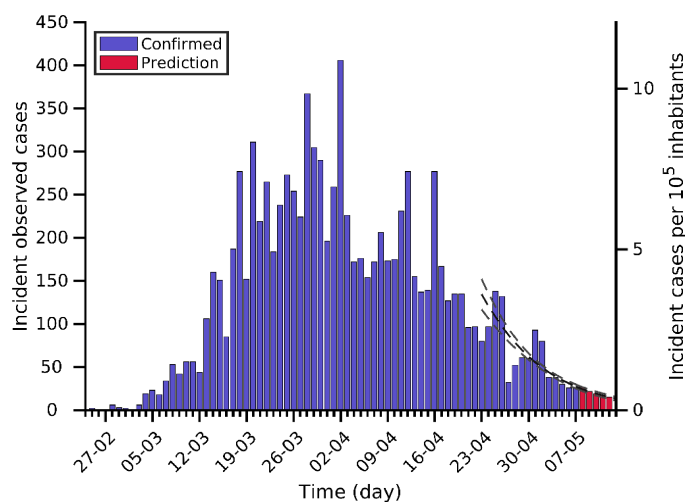
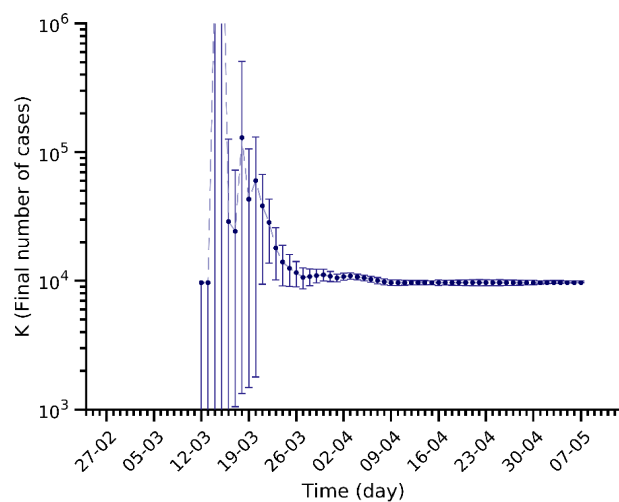
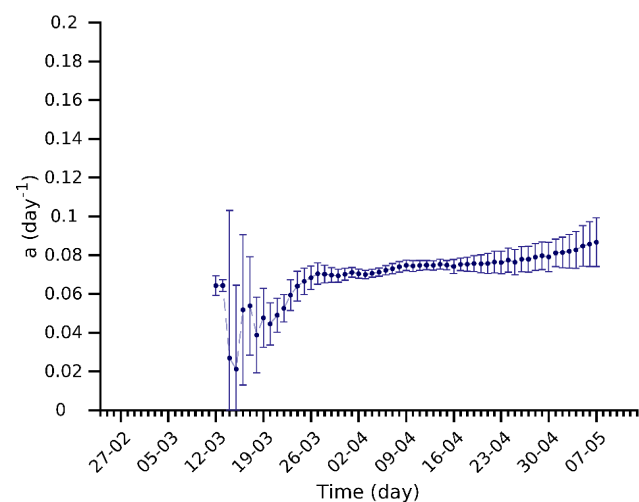
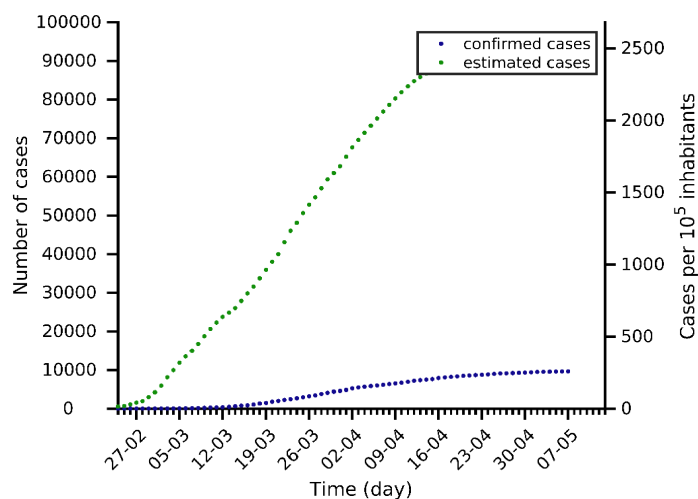
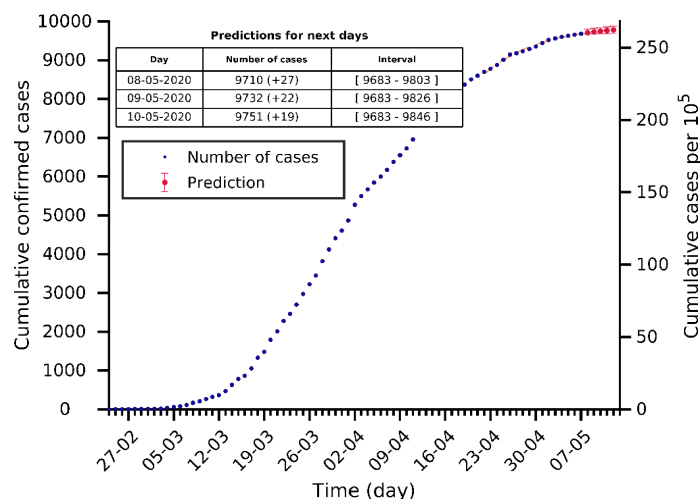
Emilia Romagna 07-05-2020. Population: 4.5M. Current cumulated incidence: 594/100000



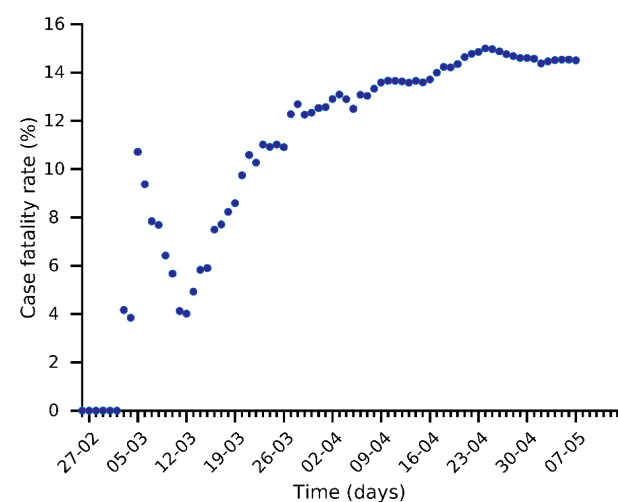
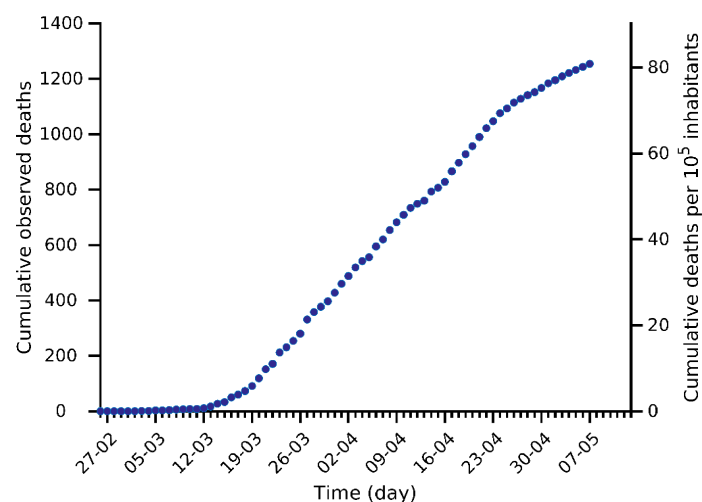
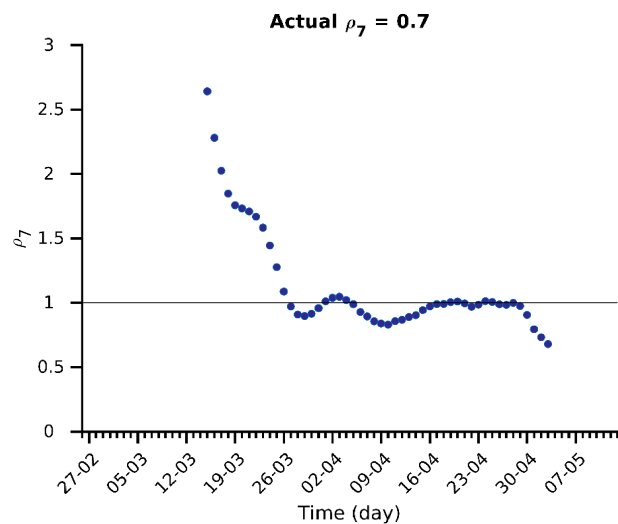
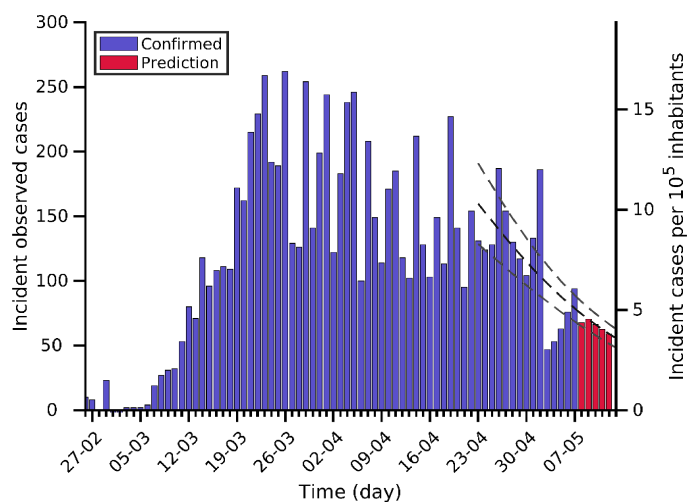
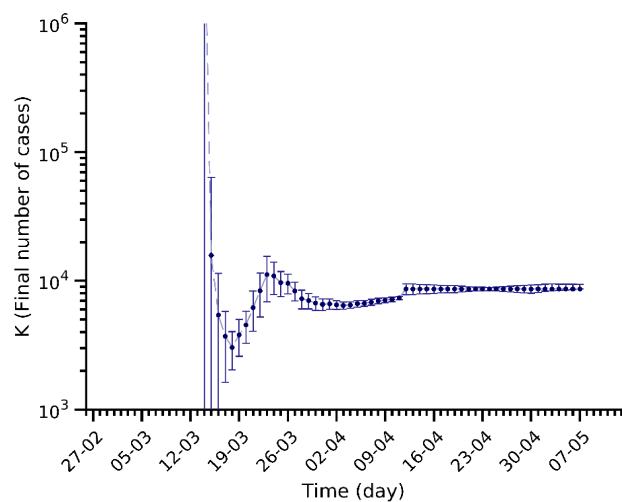
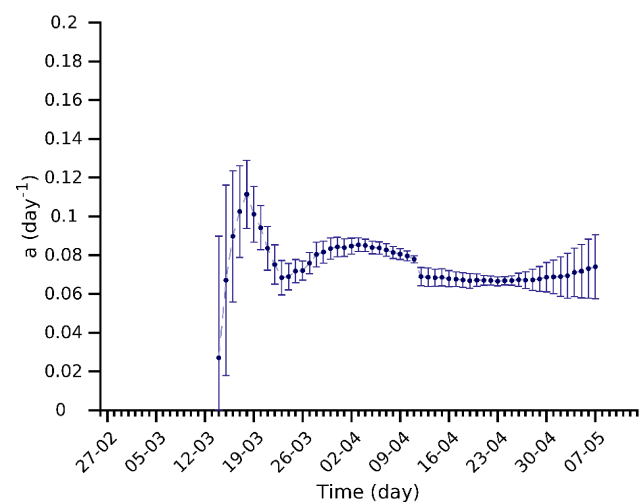
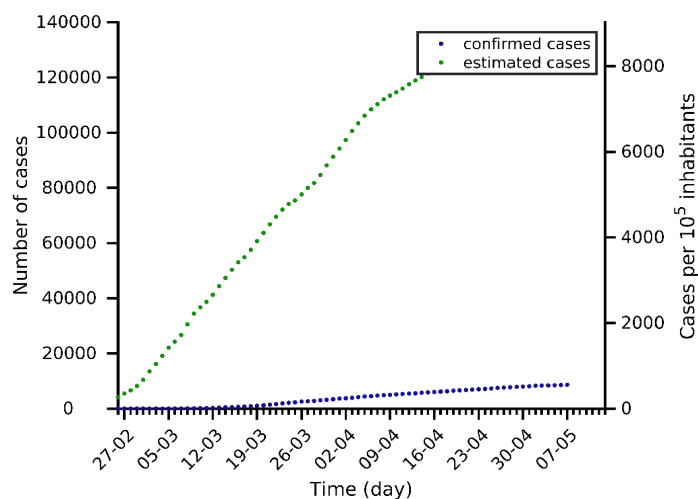
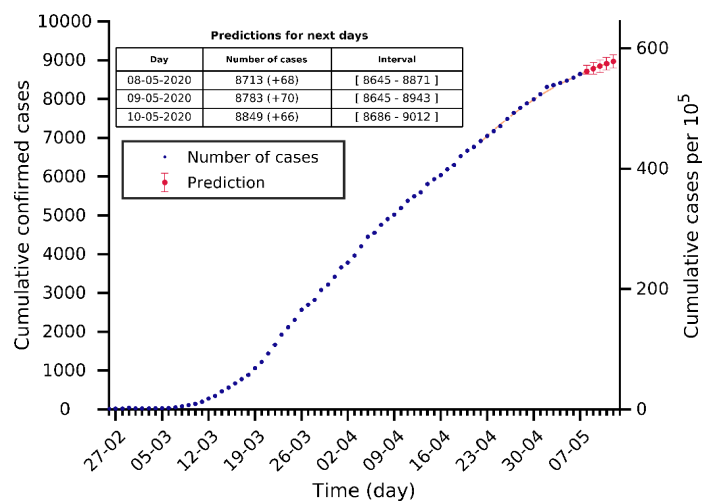
Veneto 07-05-2020. Population: 4.9M. Current cumulated incidence: 378/10⁵



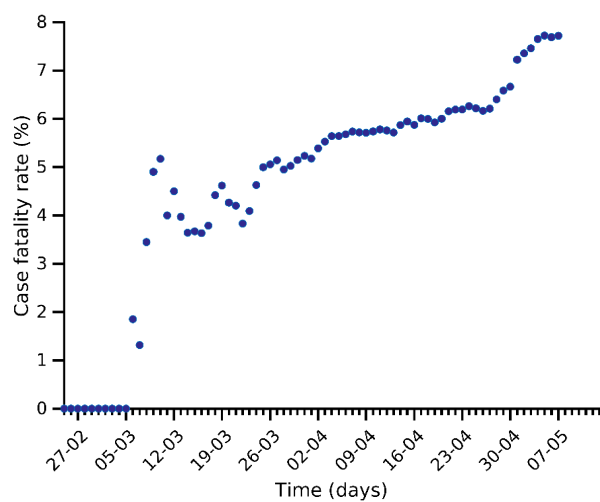
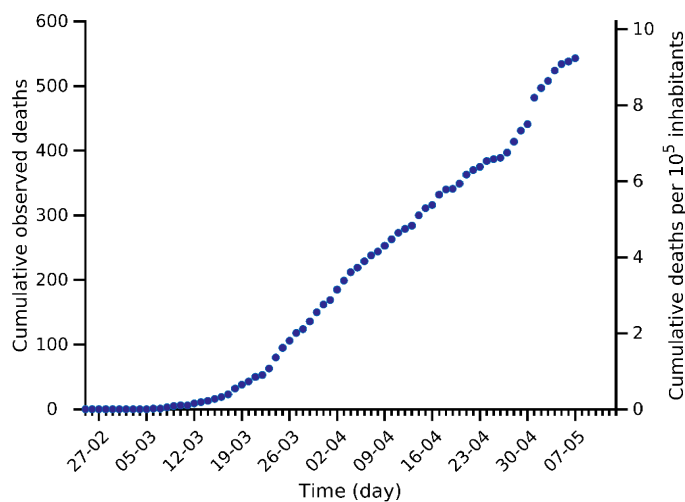
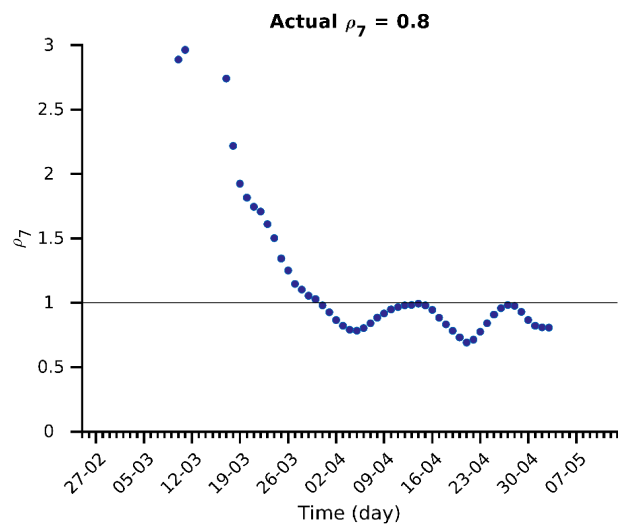
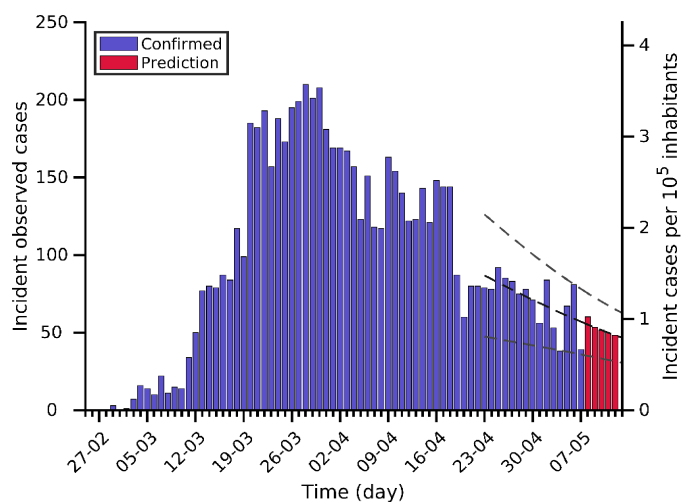
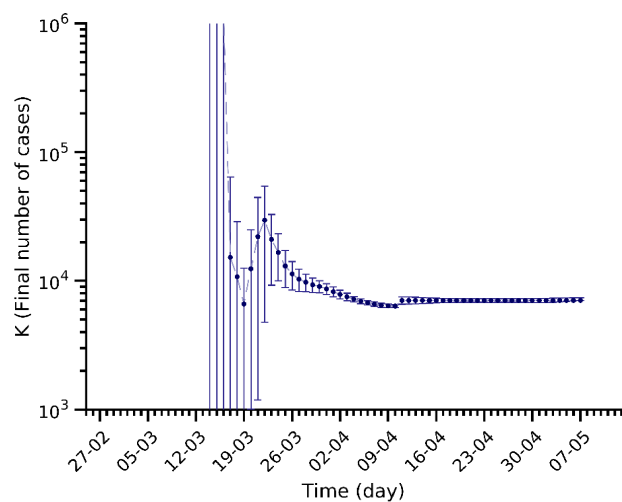
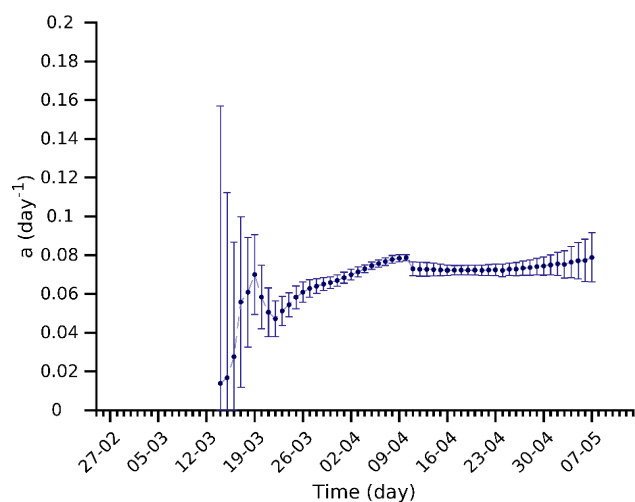
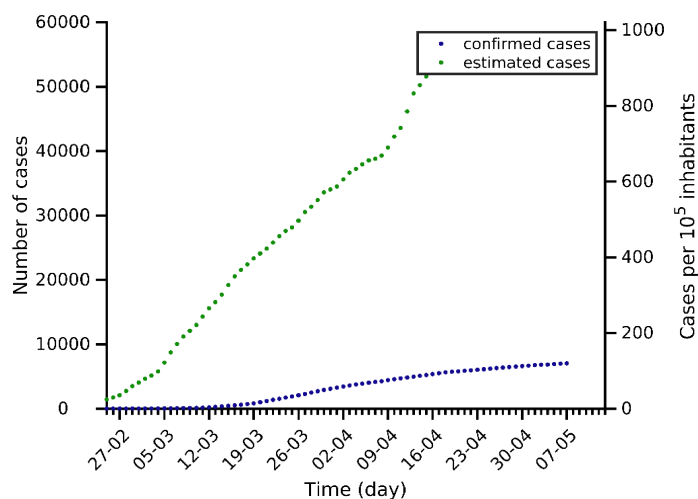
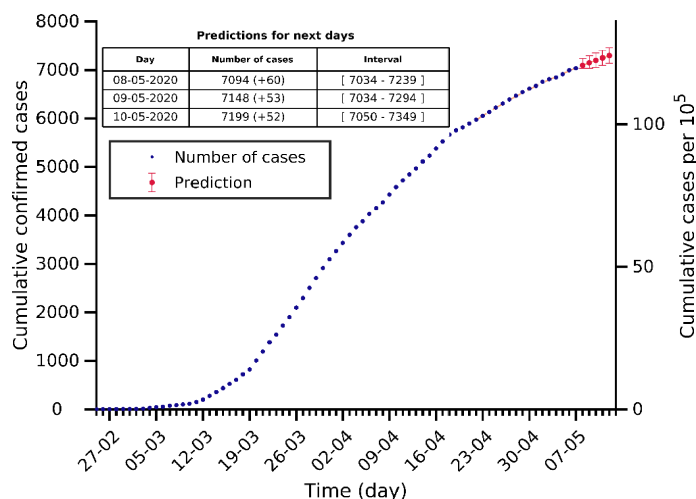
Toscana 07-05-2020. Population: 3.7M. Current cumulated incidence: 260/10⁵



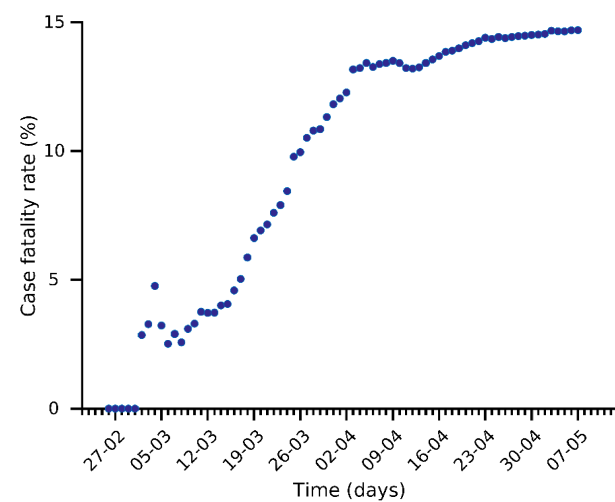
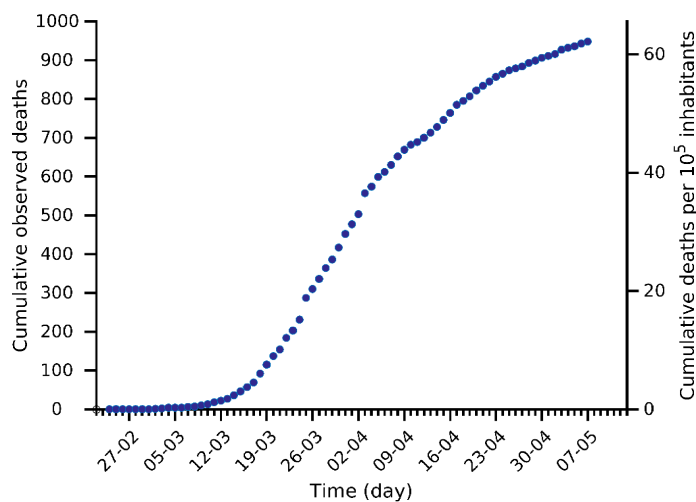
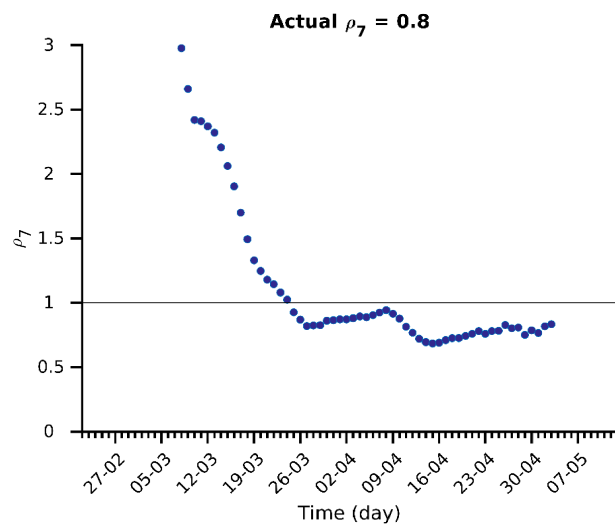
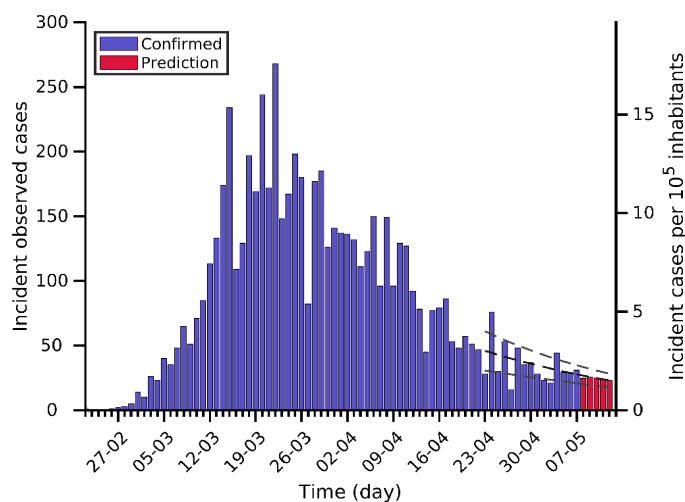
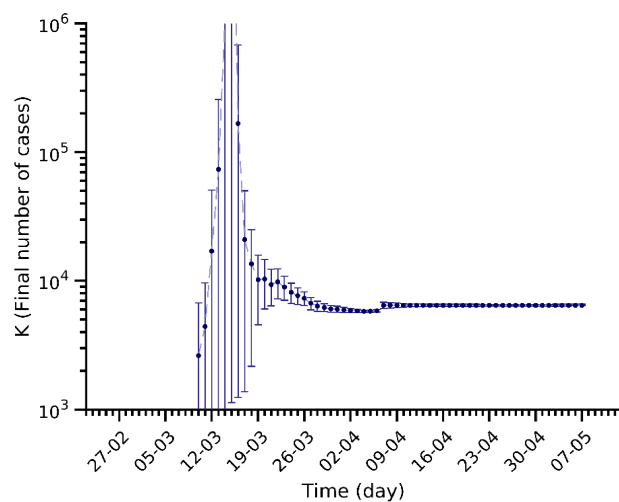
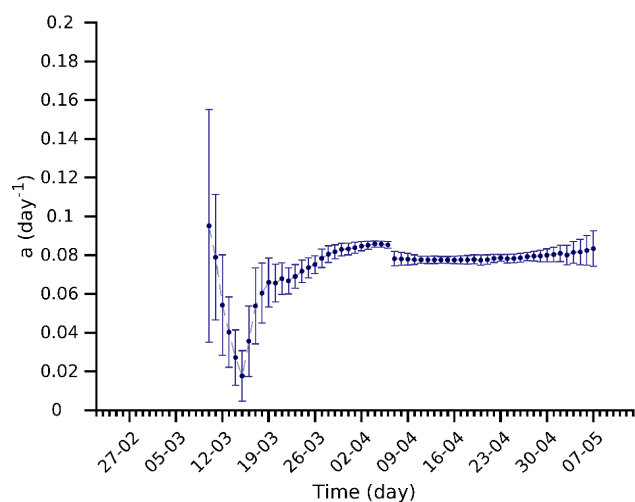
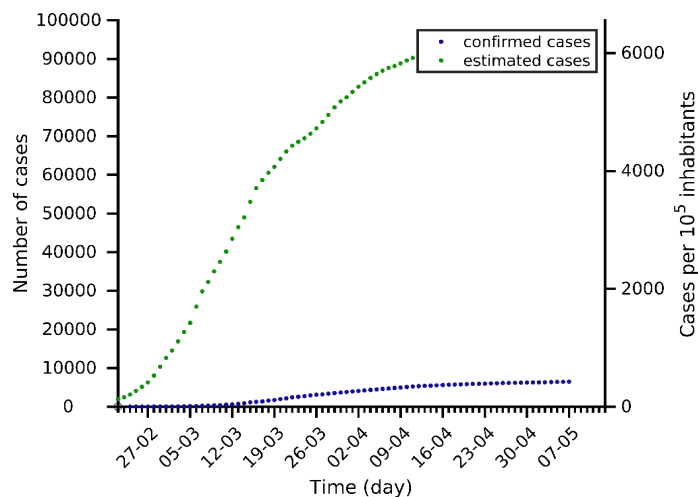
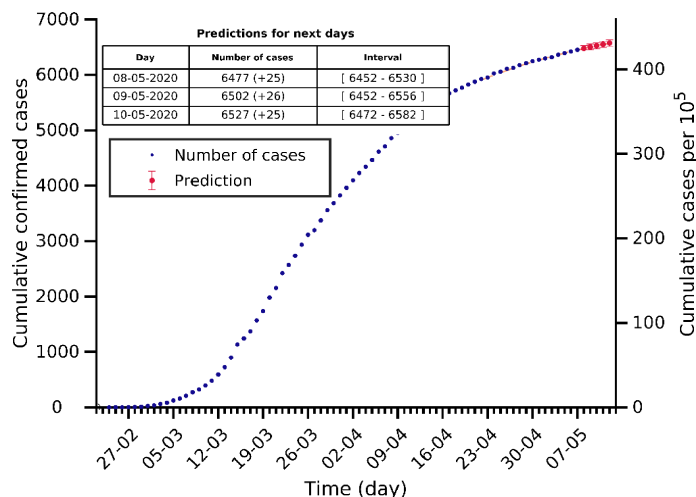
Liguria 07-05-2020. Population: 1.6M. Current cumulated incidence: 557/10⁵



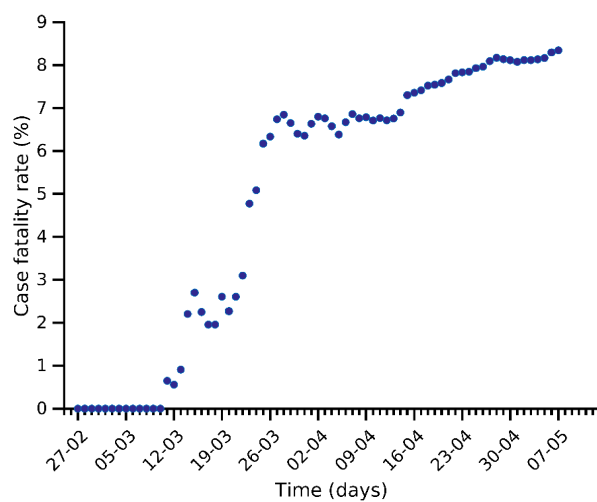
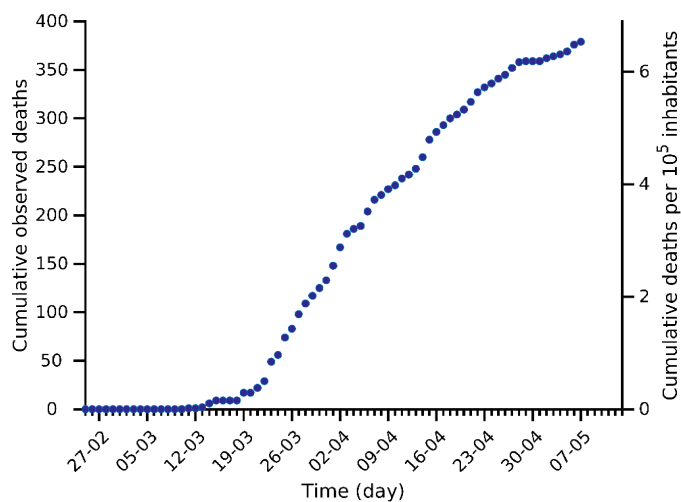
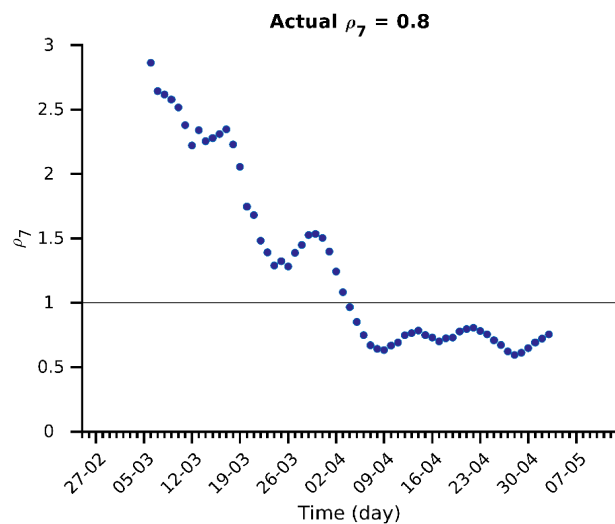
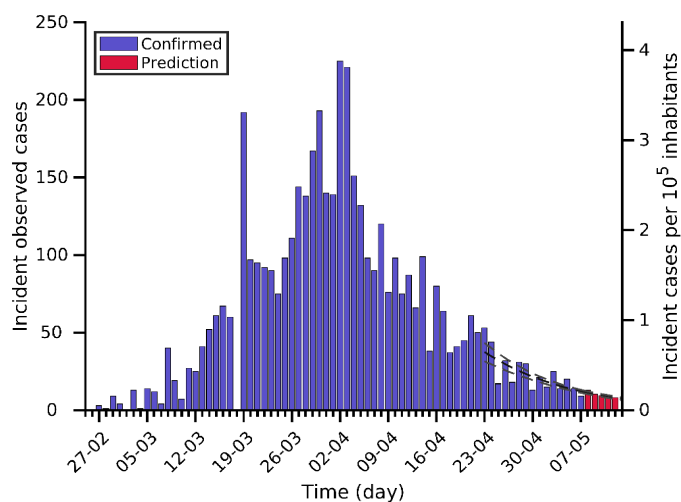
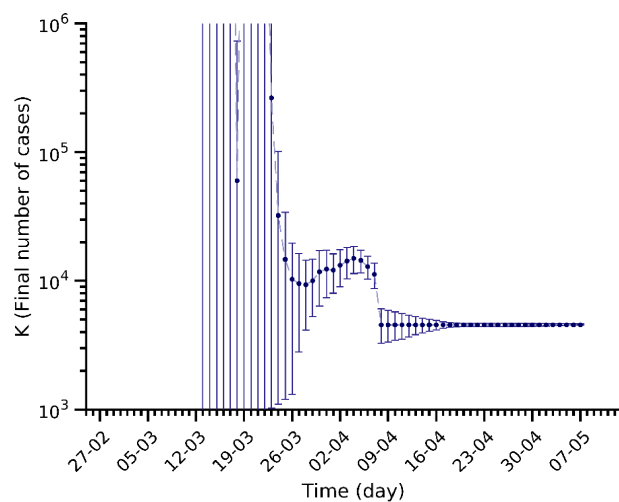
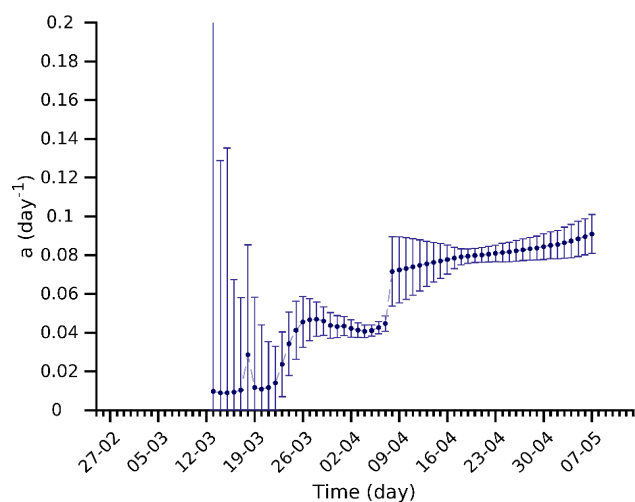
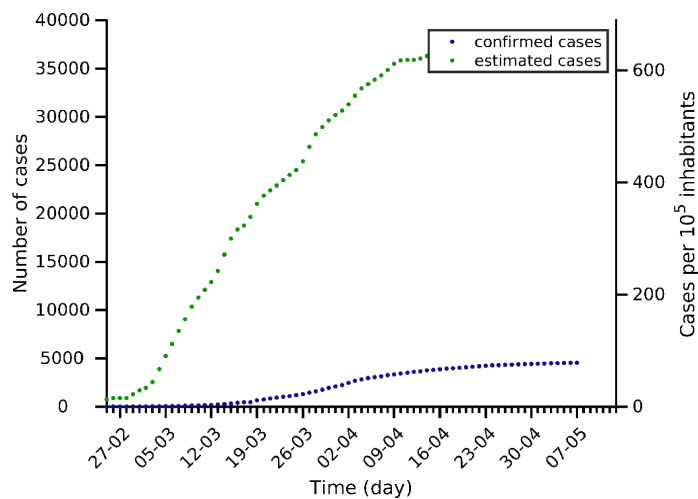
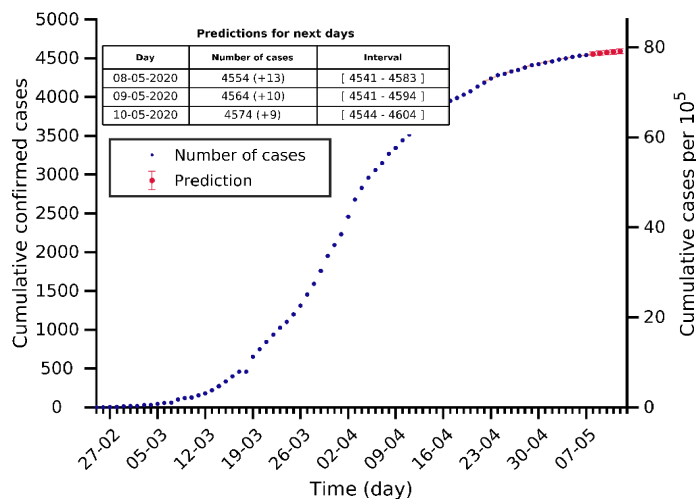
Lazio 07-05-2020. Population: 5.9M. Current cumulated incidence: 120/10⁵



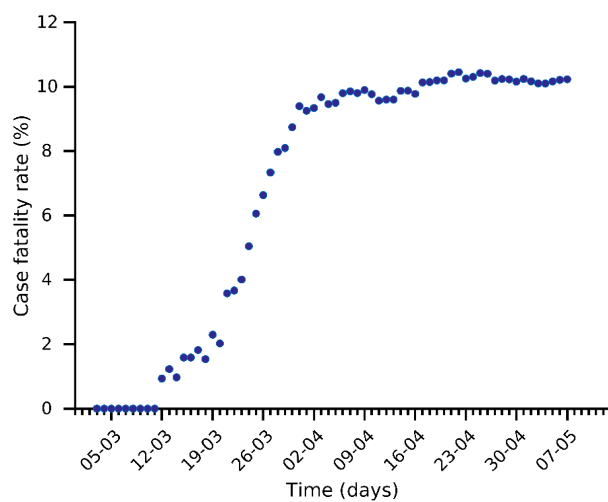
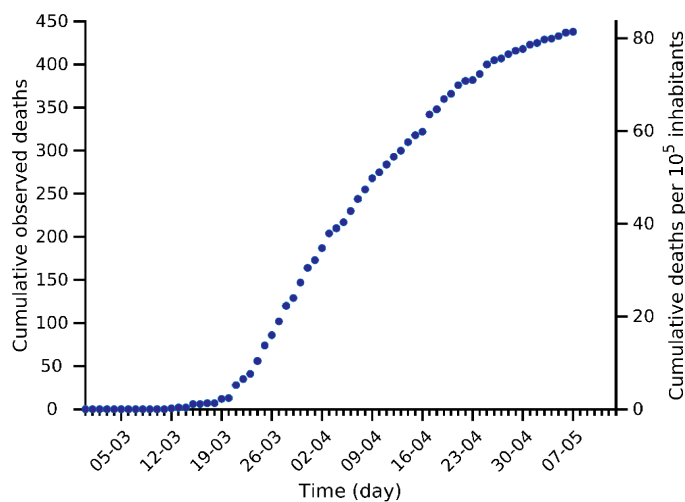
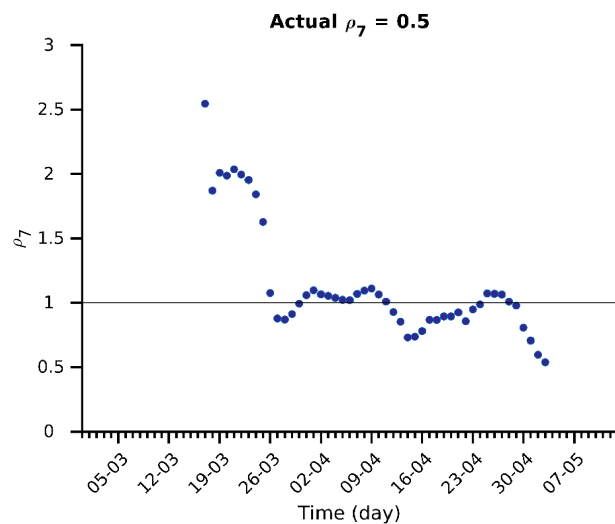
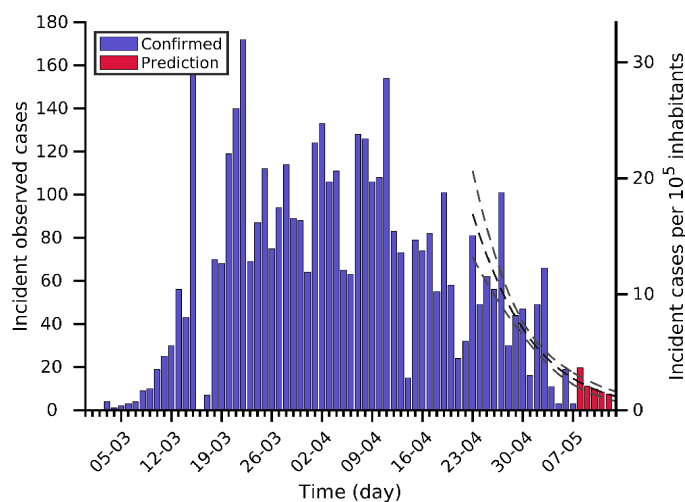
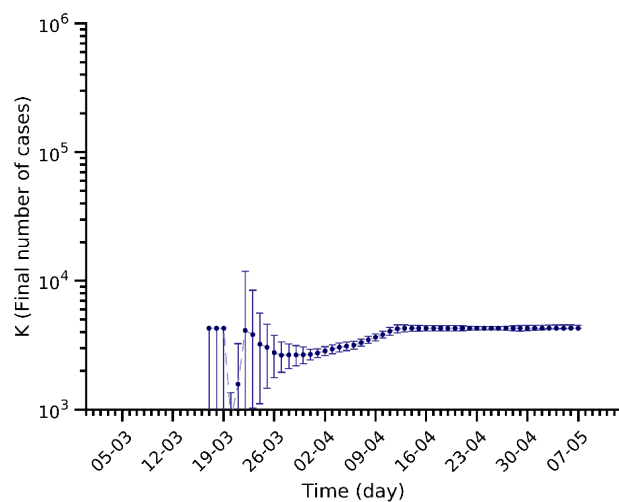
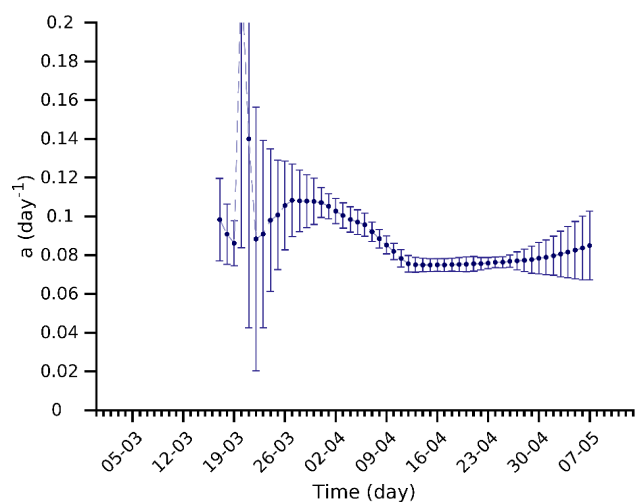
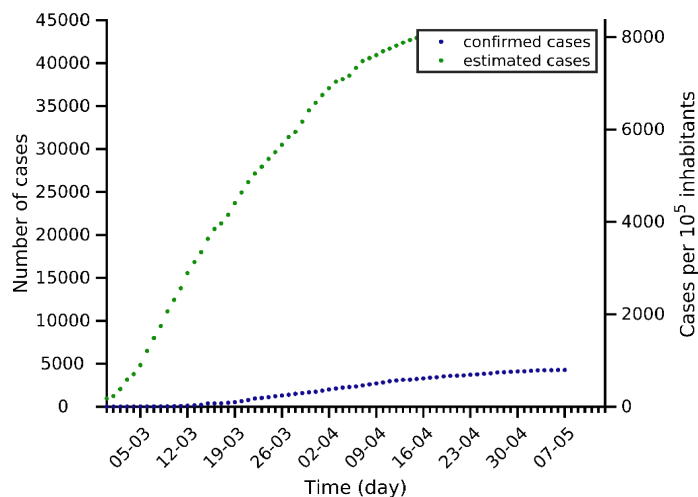
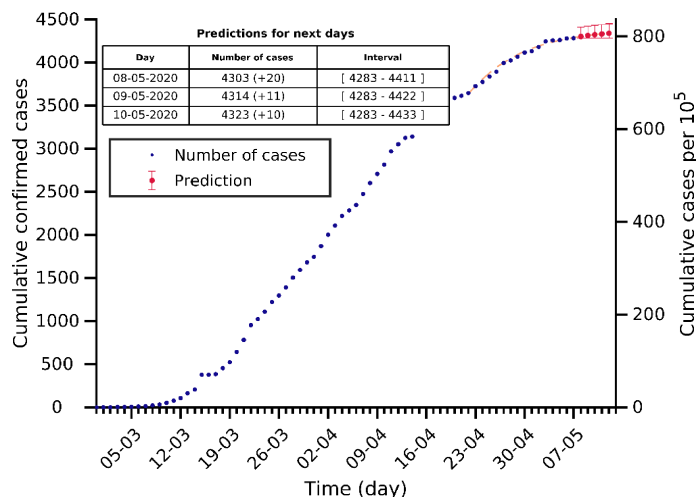
Marche 07-05-2020. Population: 1.5M. Current cumulated incidence: 423/10⁵



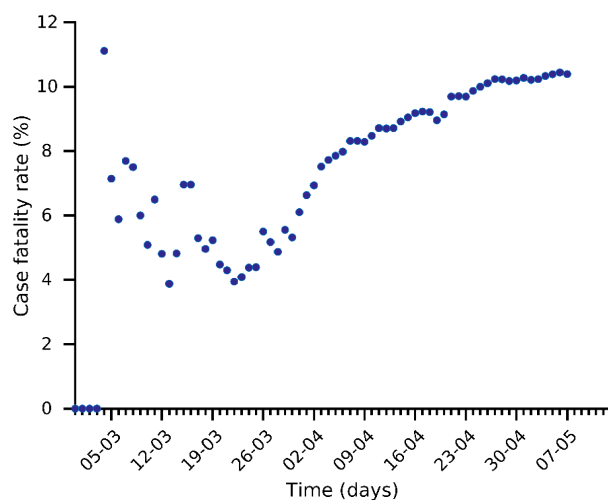
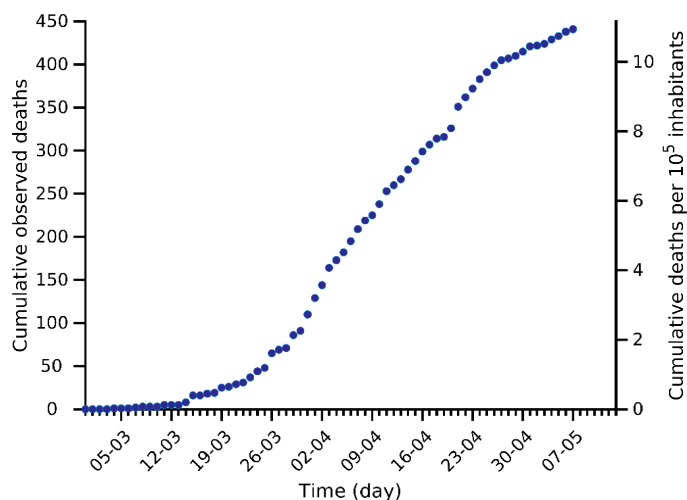
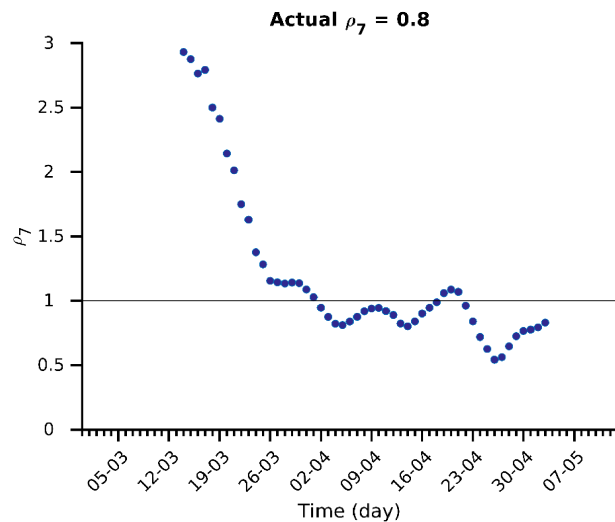
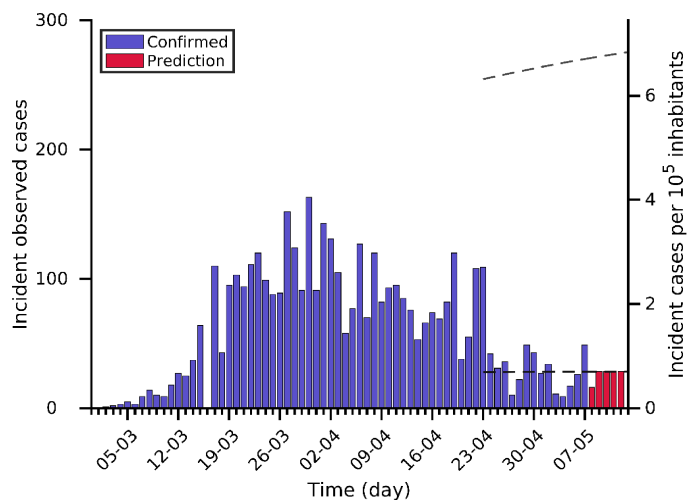
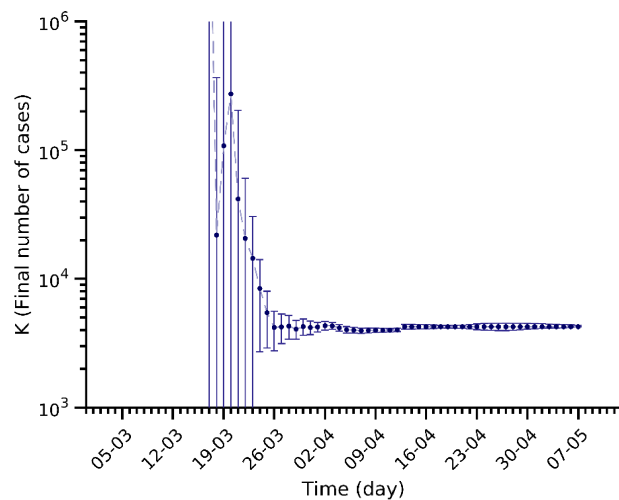
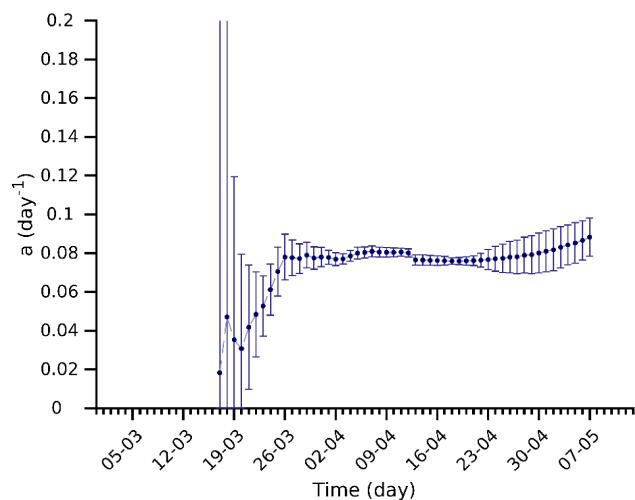
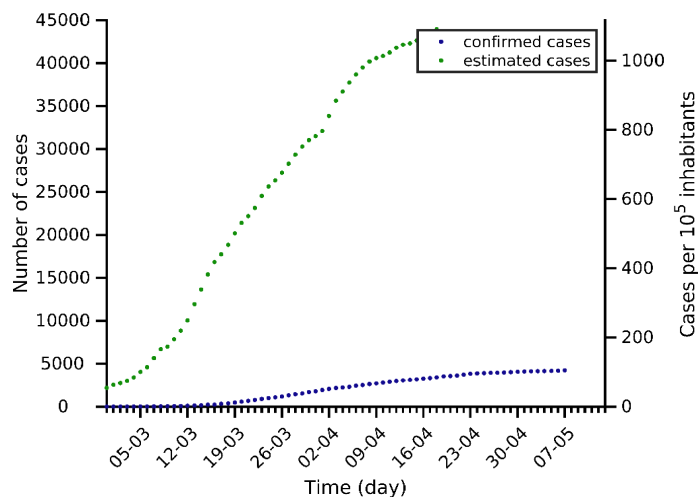
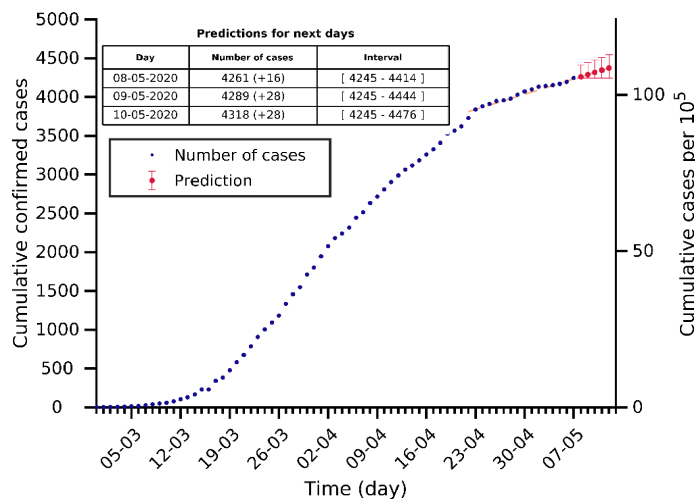
Campania 07-05-2020. Population: 5.8M. Current cumulated incidence: 78/10⁵



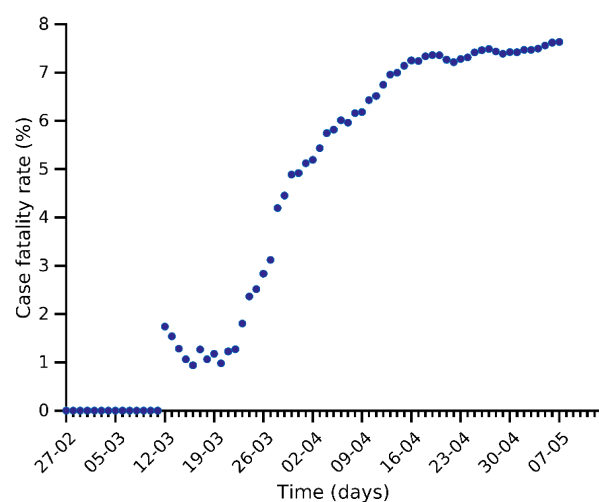
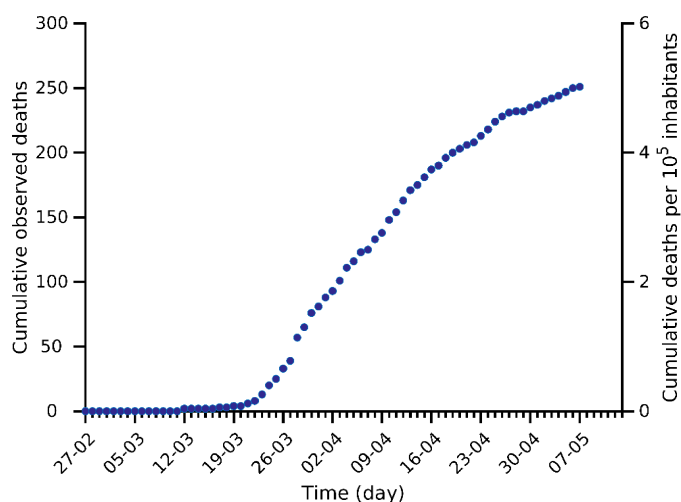
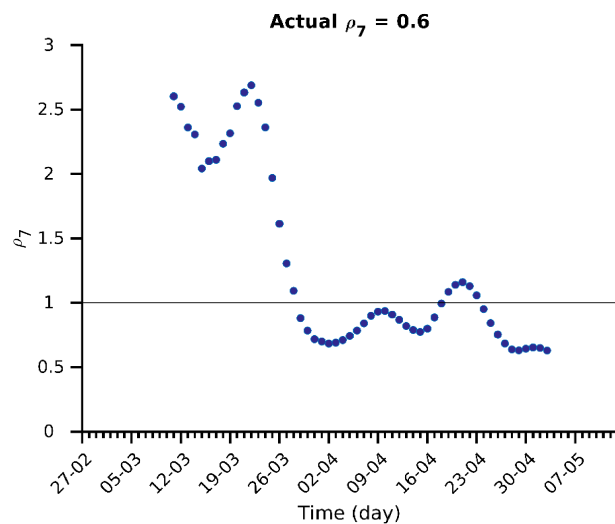
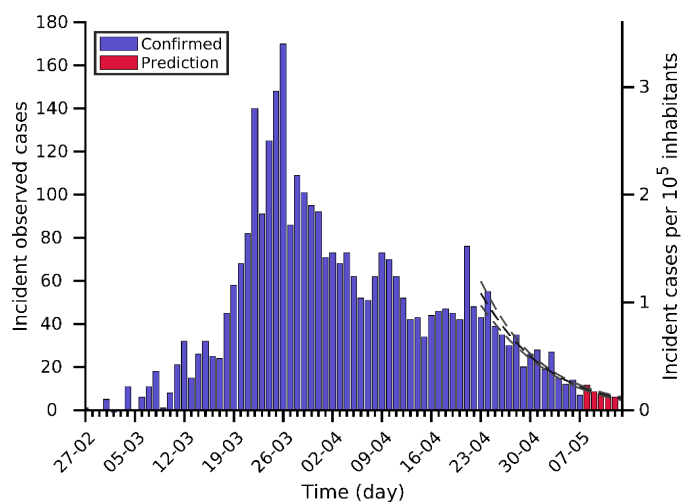
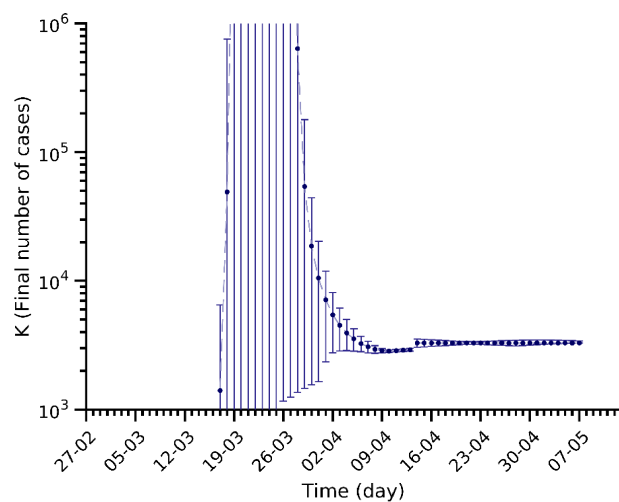
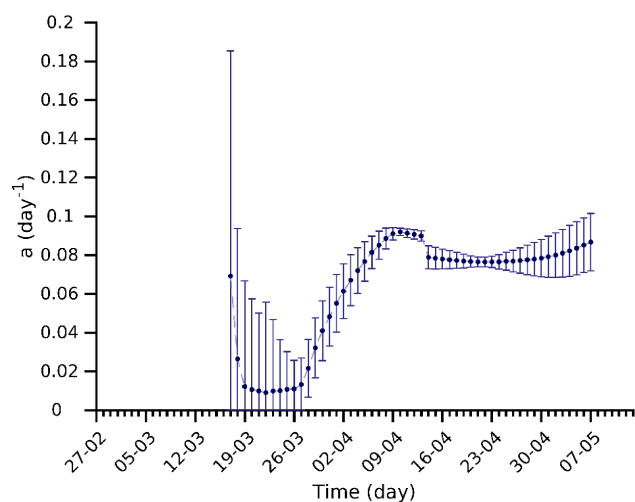
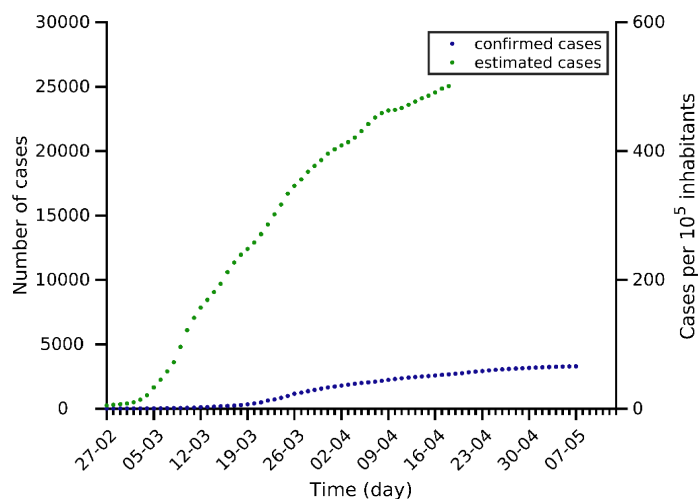
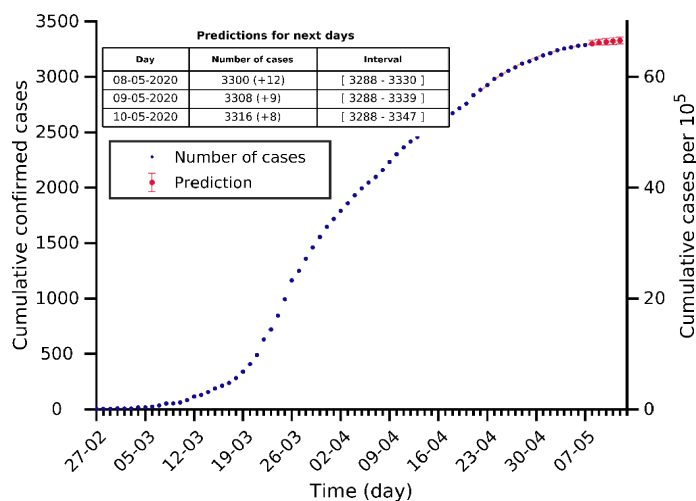
Trento 07-05-2020. Population: 0.5M. Current cumulated incidence: 796/10⁵



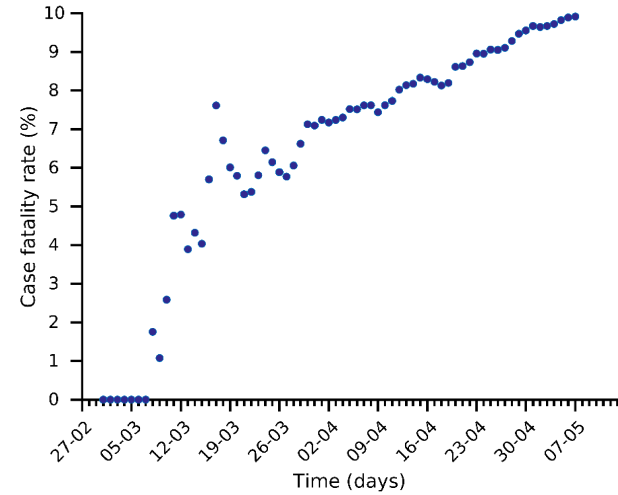
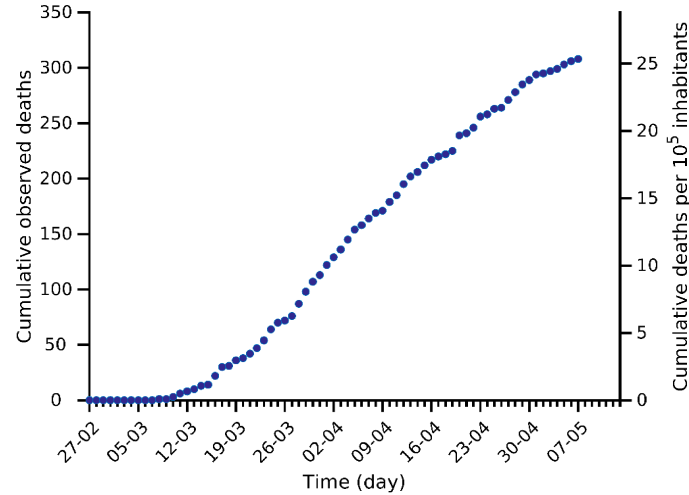
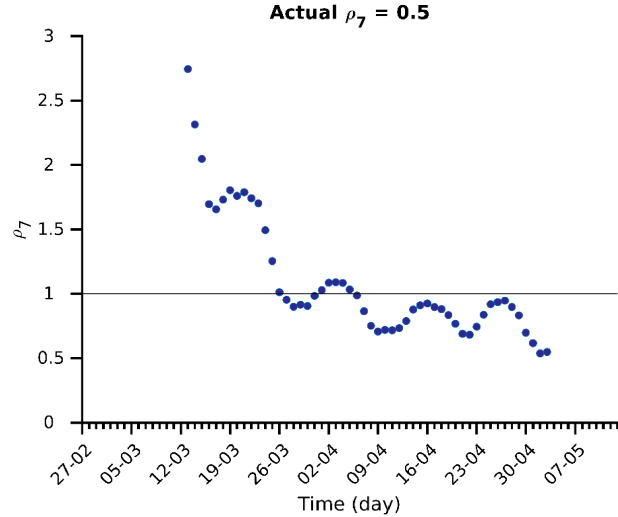
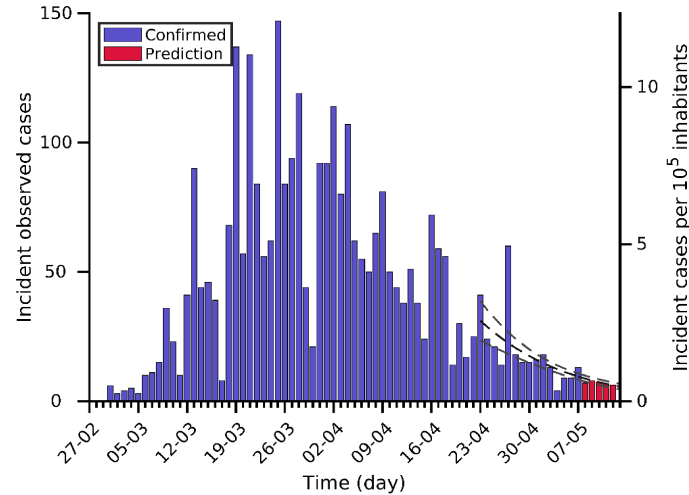
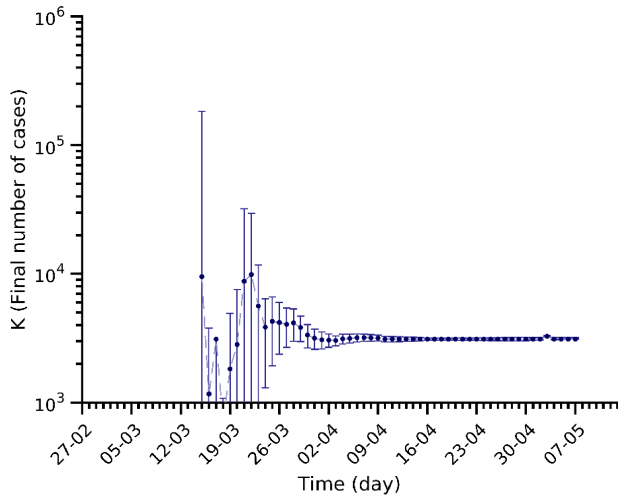
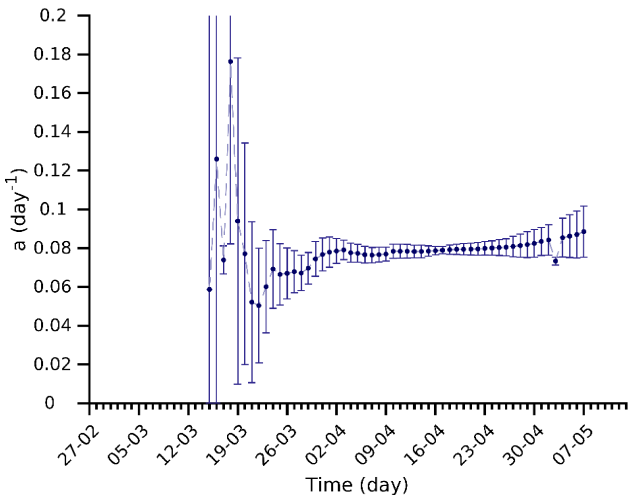
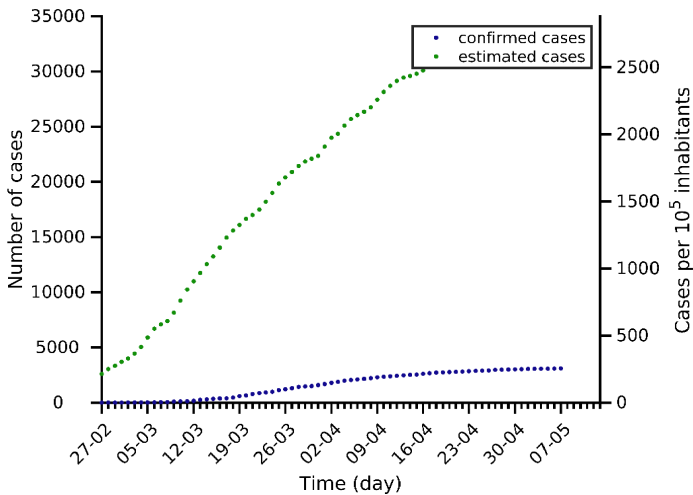
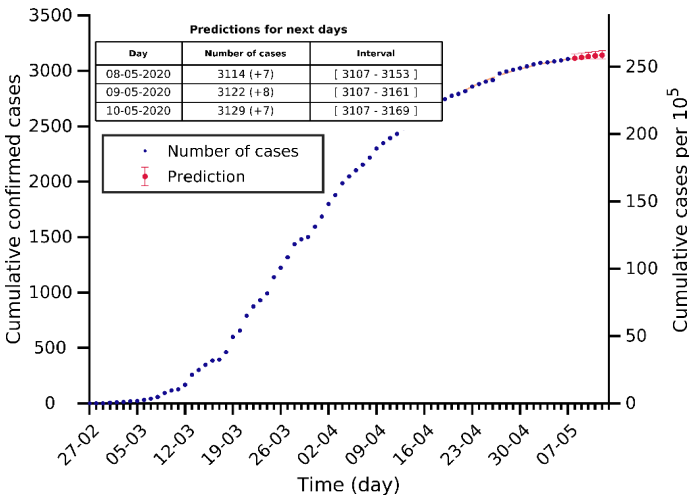
Puglia 07-05-2020. Population: 4.0M. Current cumulated incidence: 105/10⁵



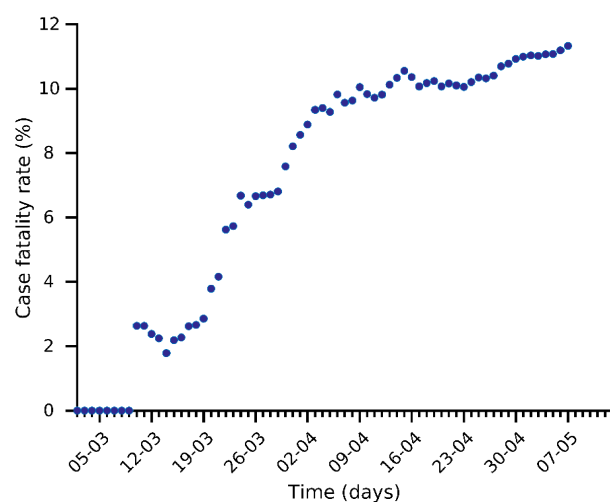
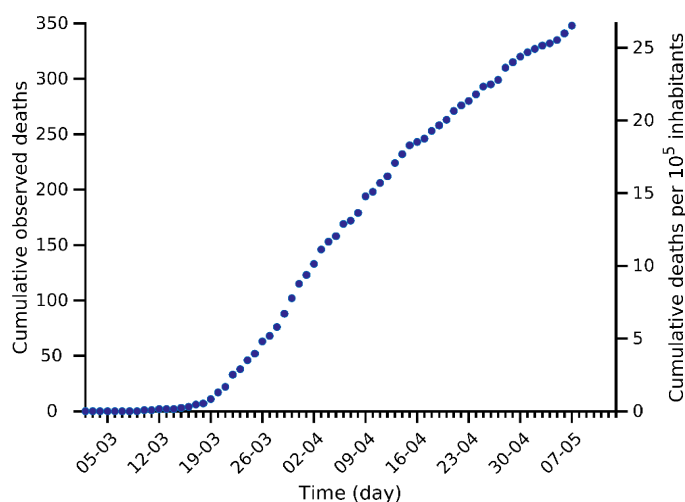
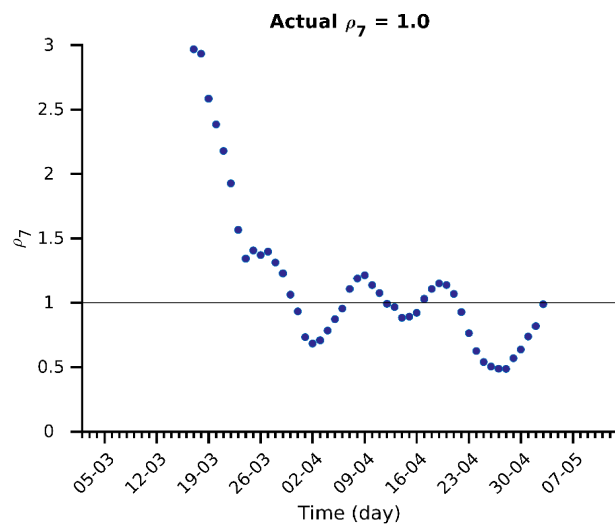
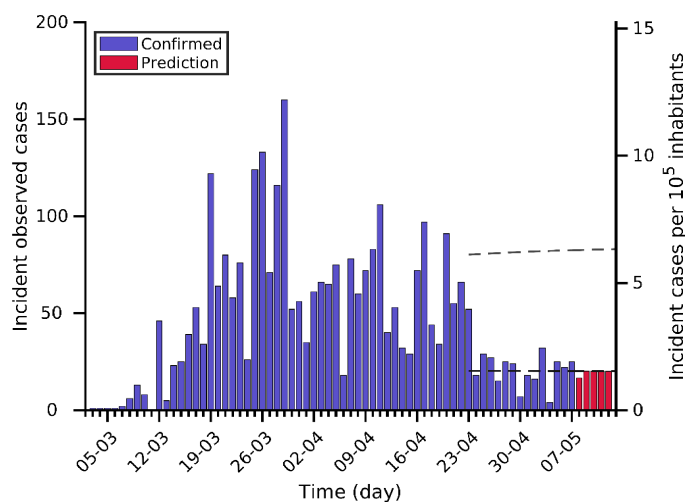
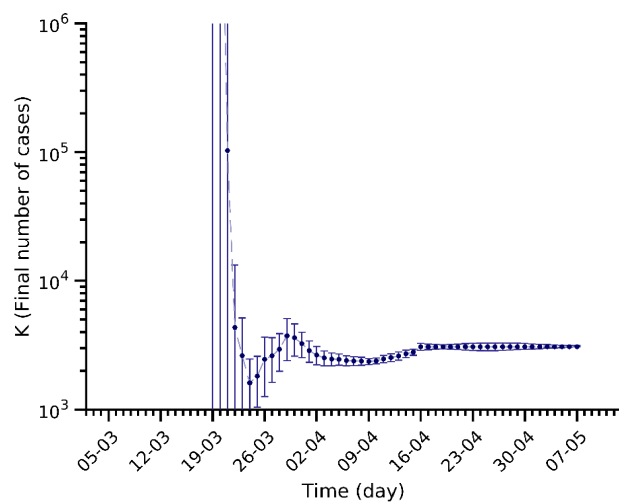
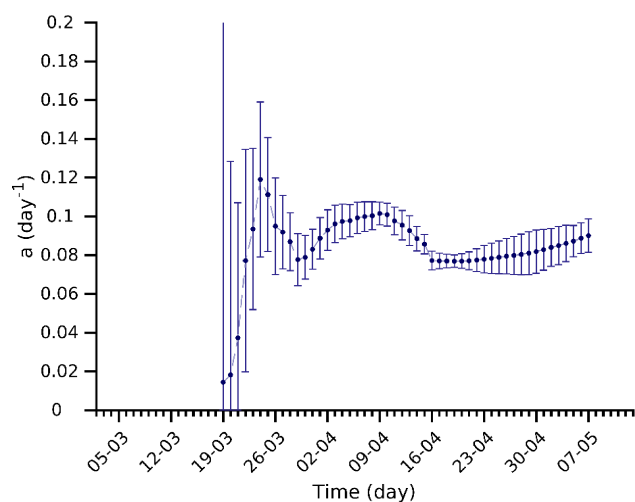
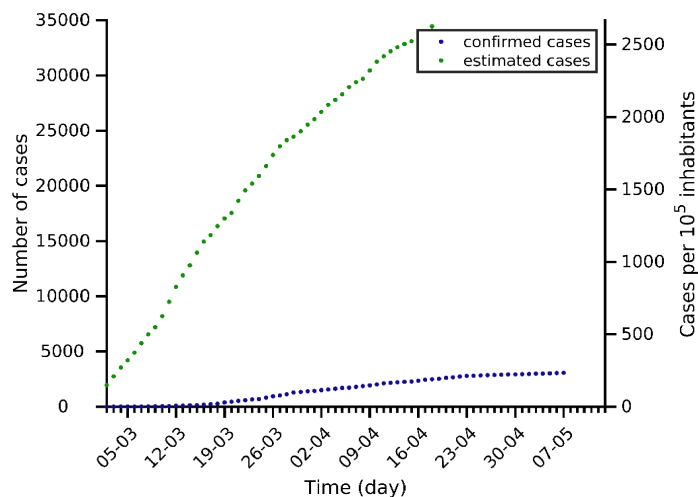
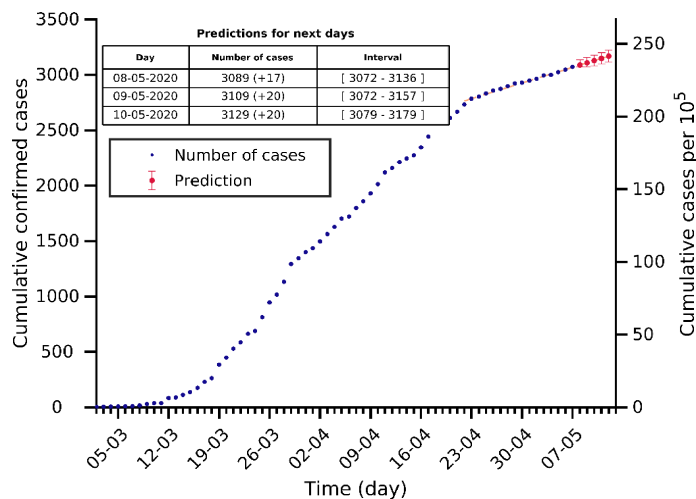
Sicilia 07-05-2020. Population: 5.0M. Current cumulated incidence: 66/10⁵

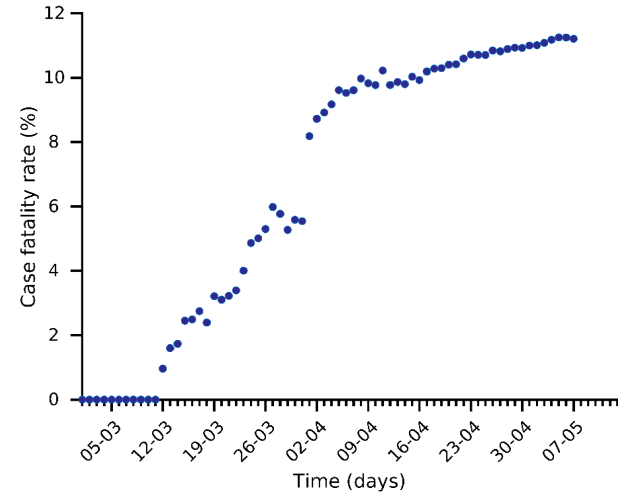
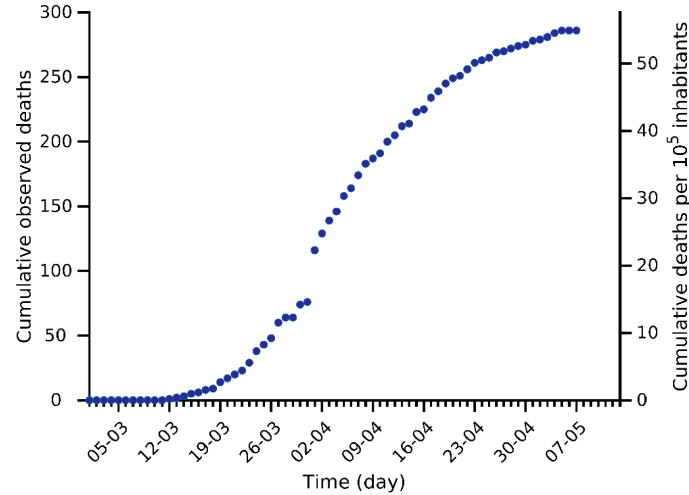
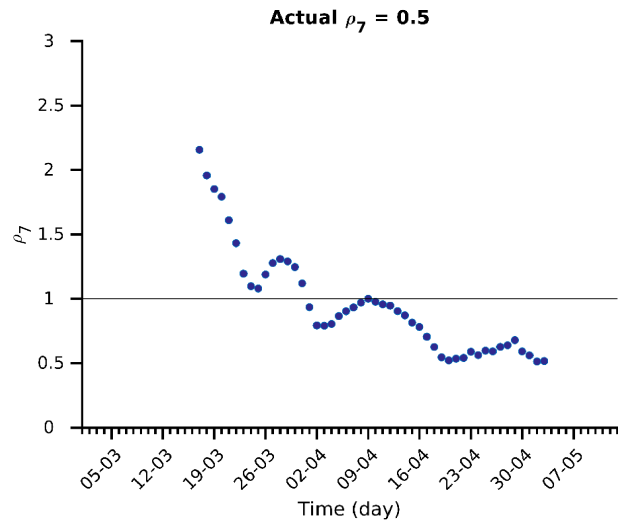
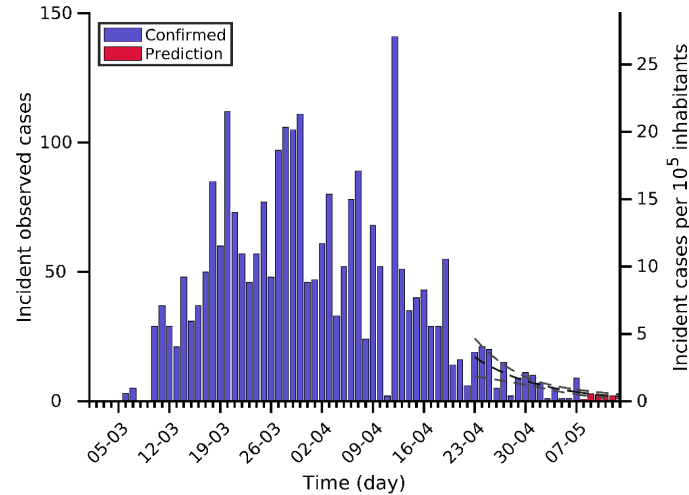
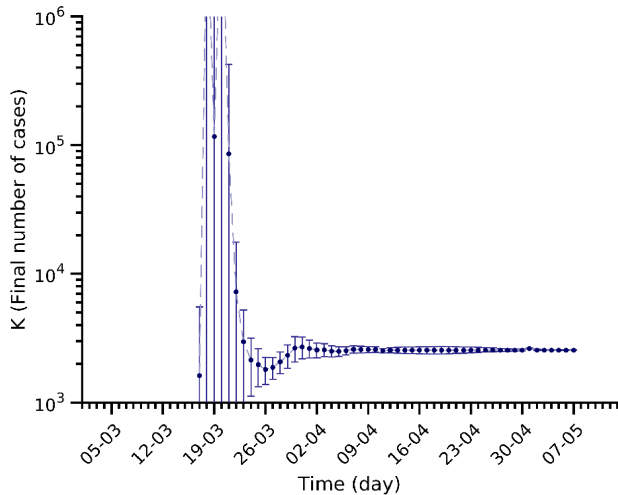
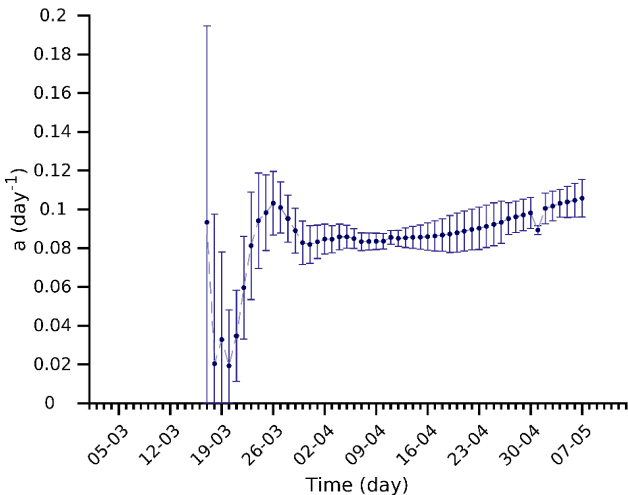
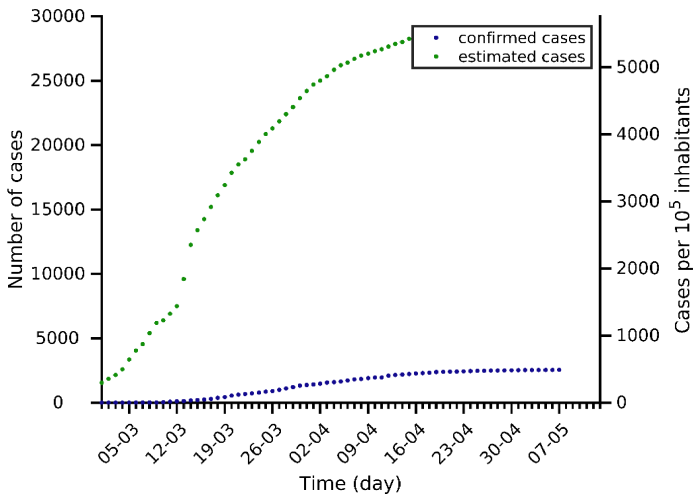
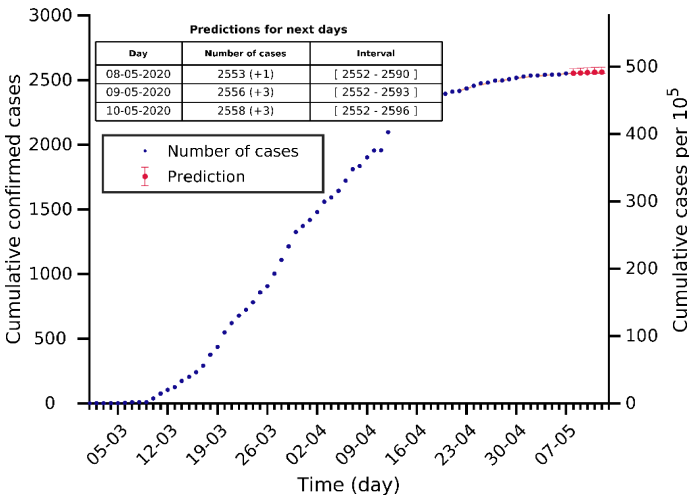


Friuli Venezia Giulia 07-05-2020. Population: 1.2M. Current cumulated incidence: 2

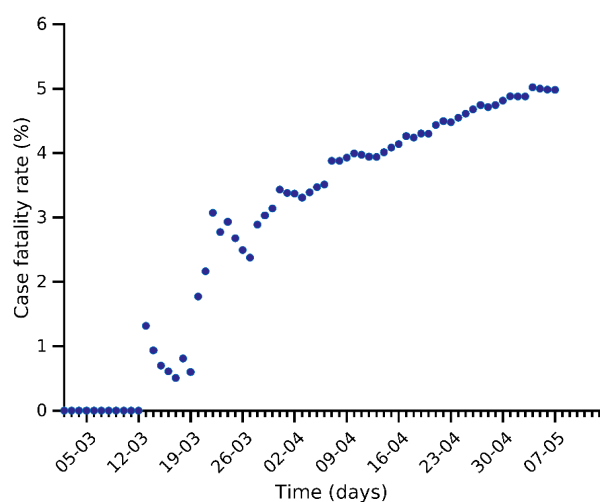
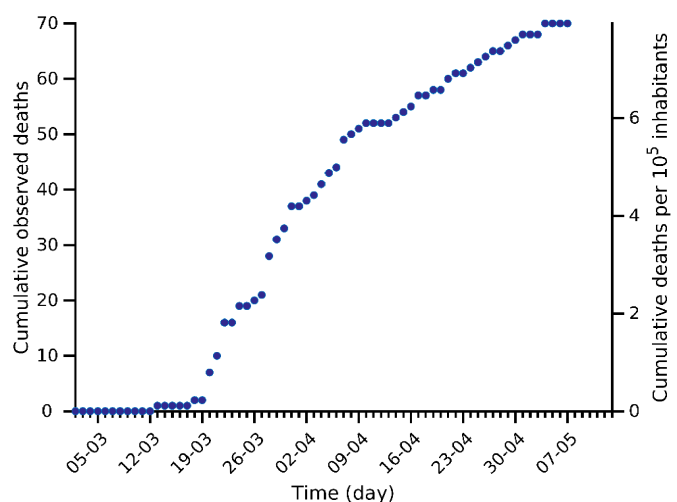
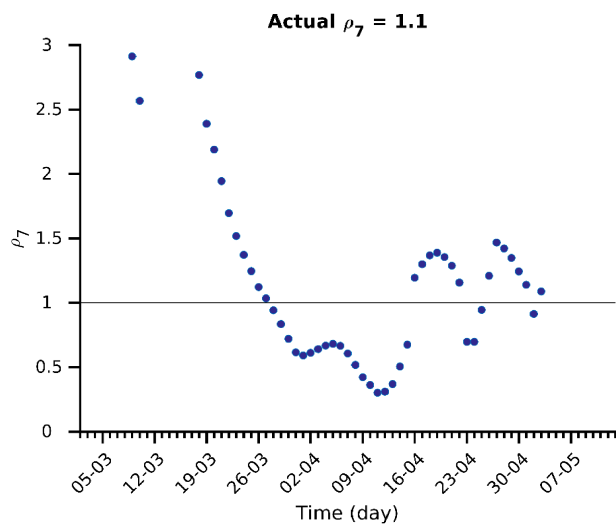
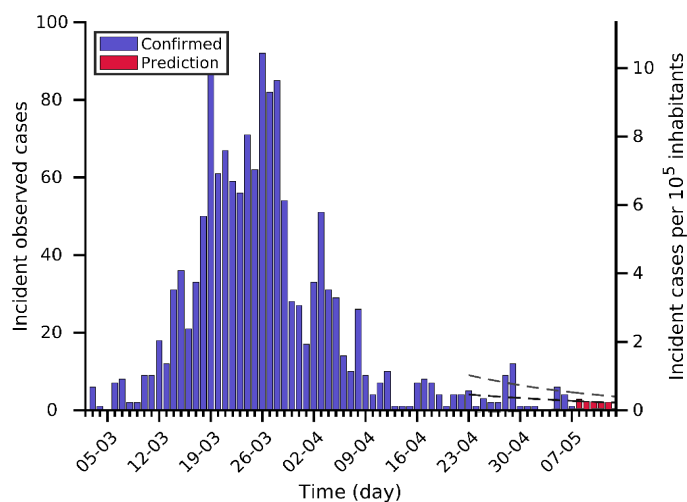
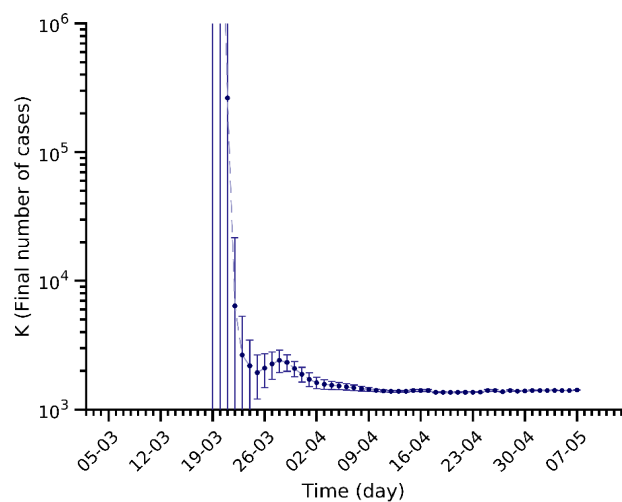
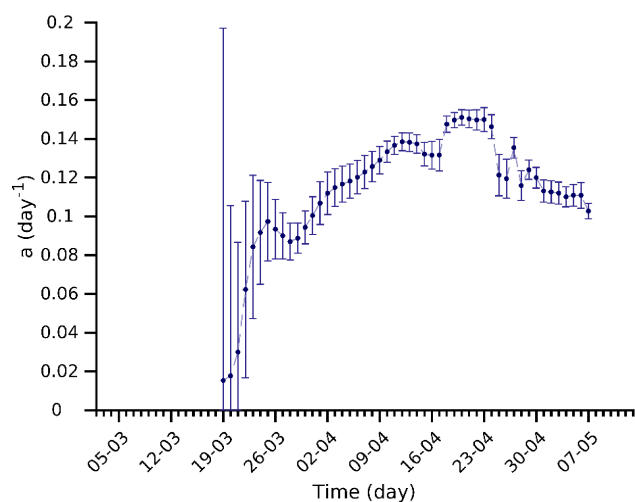
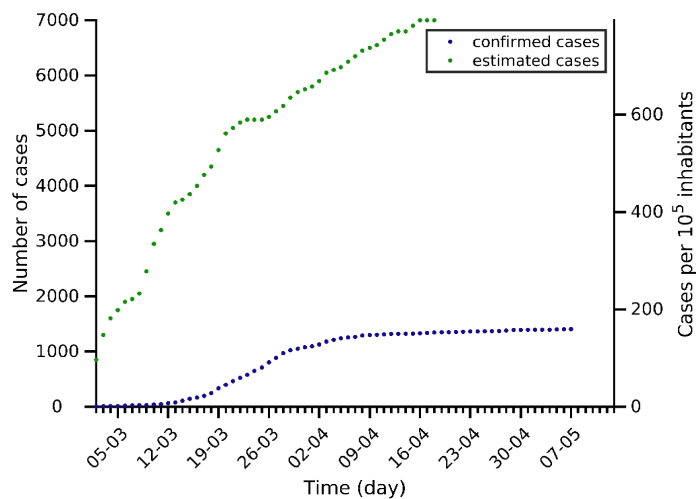
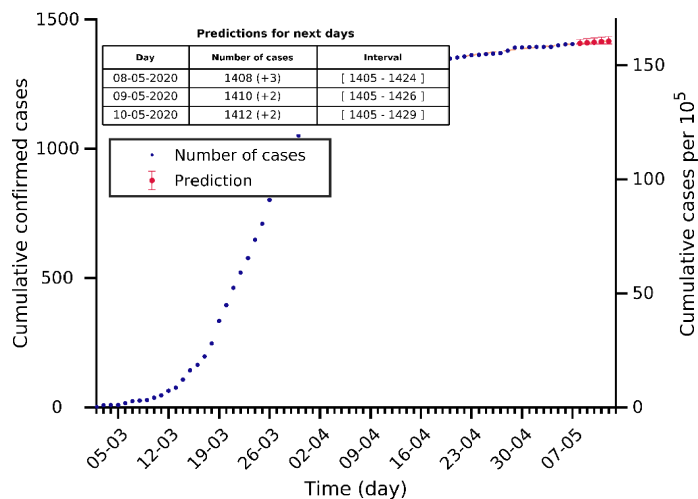


Abruzzo 07-05-2020. Population: 1.3M. Current cumulated incidence: 234/10⁵

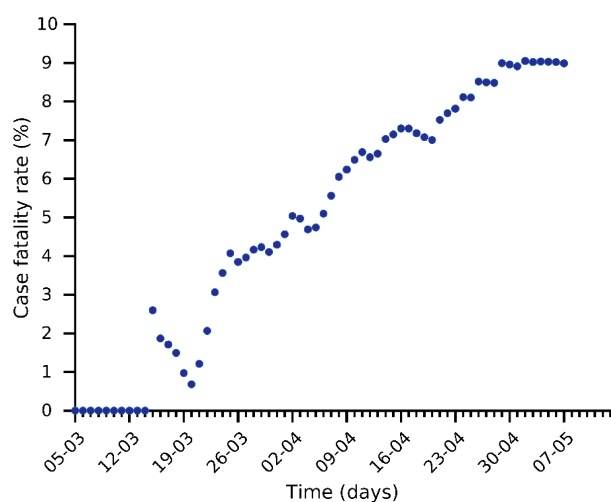
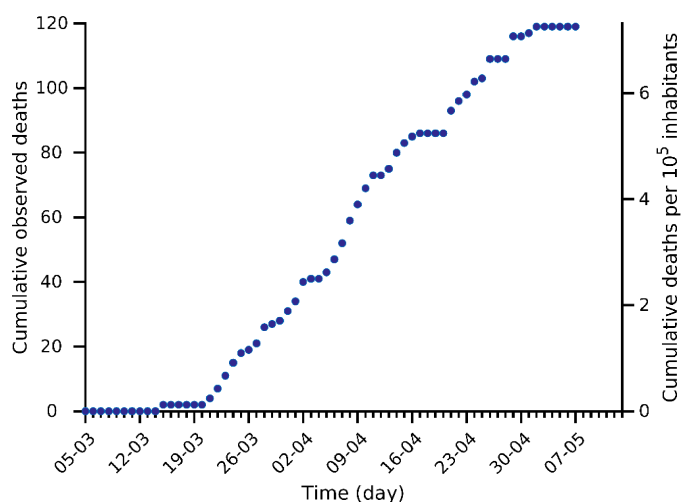
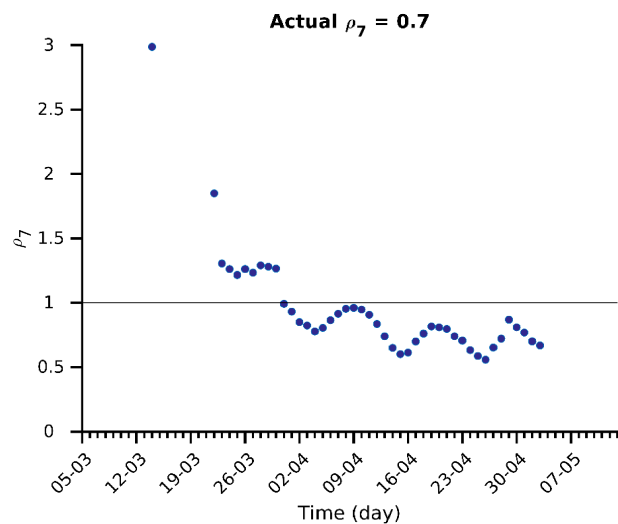
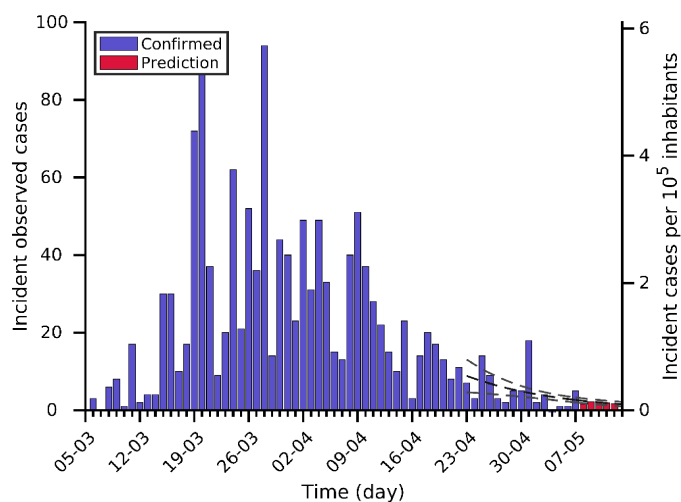
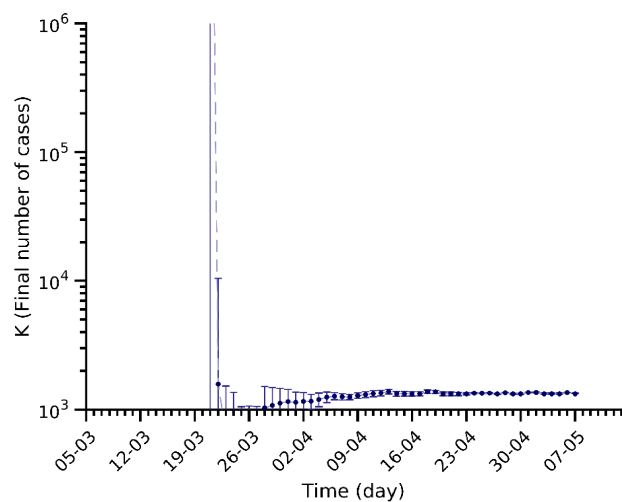
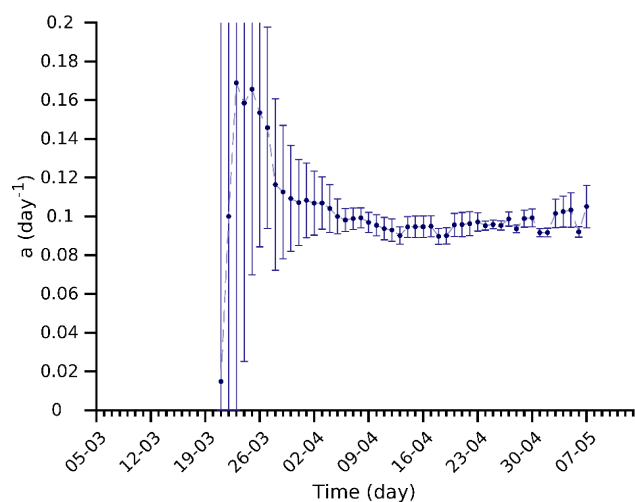
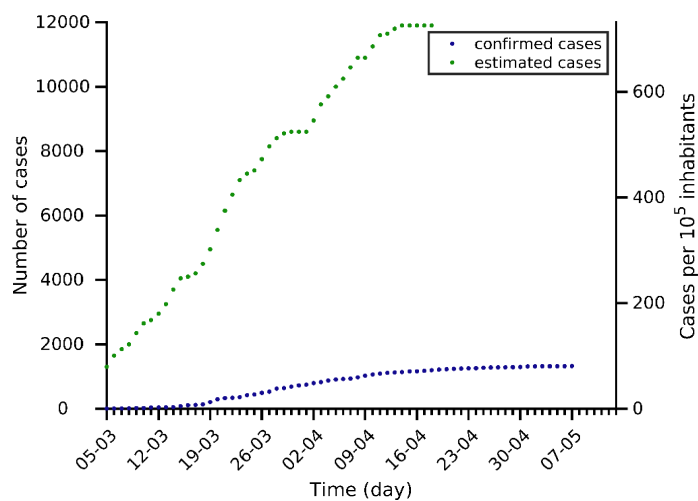
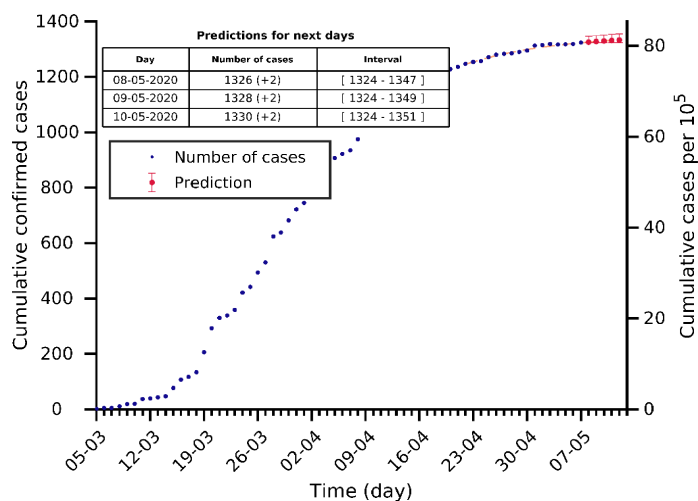




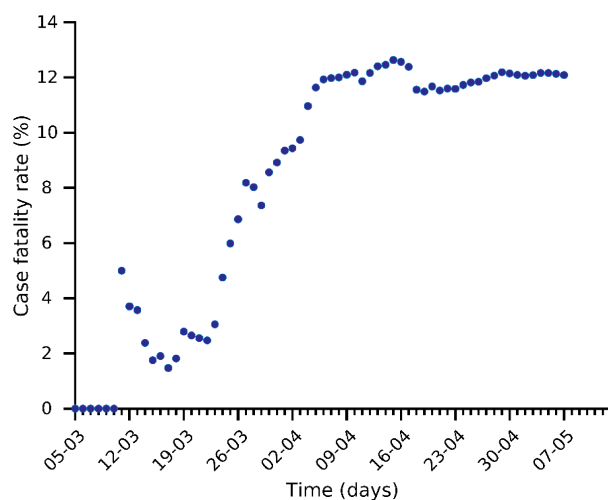
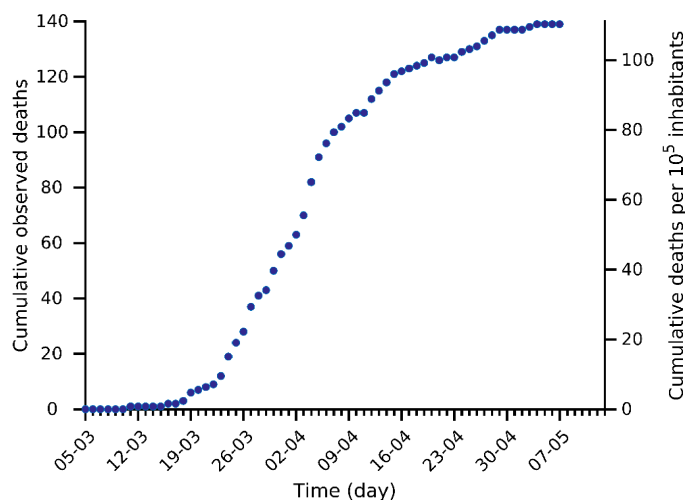
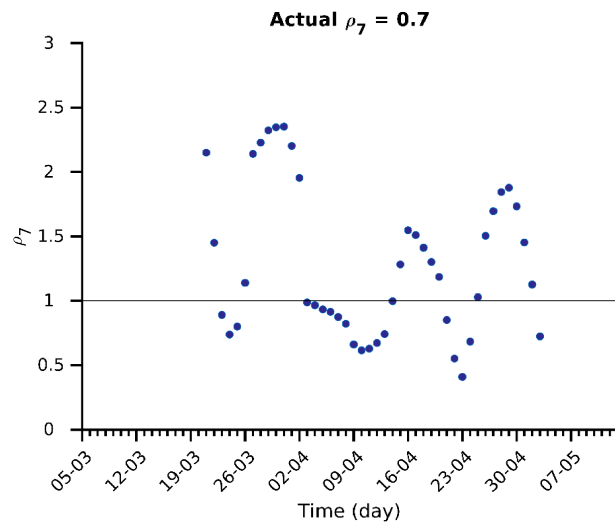
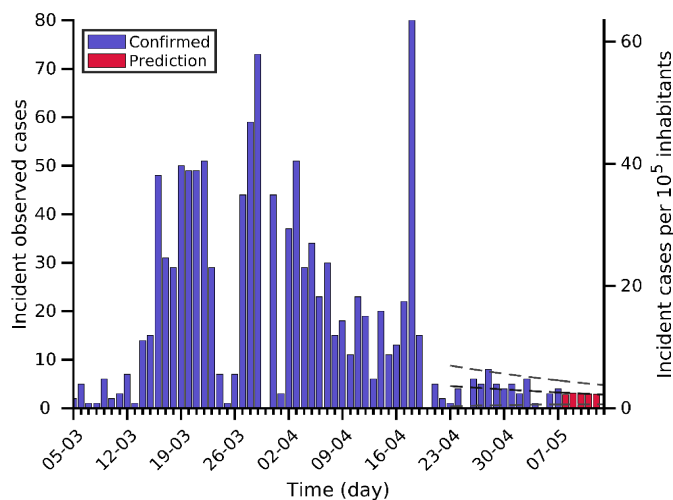
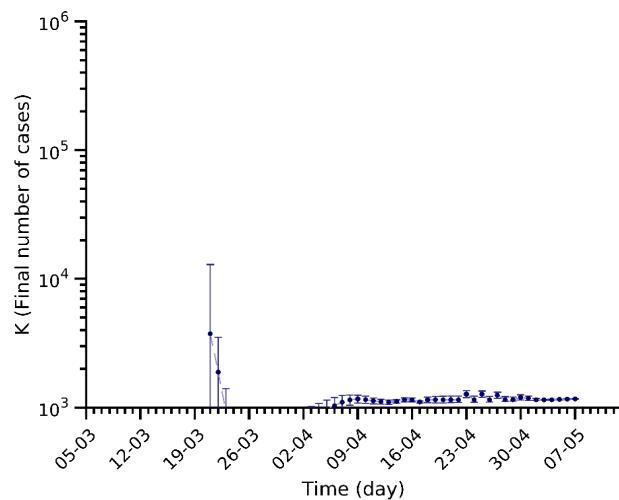
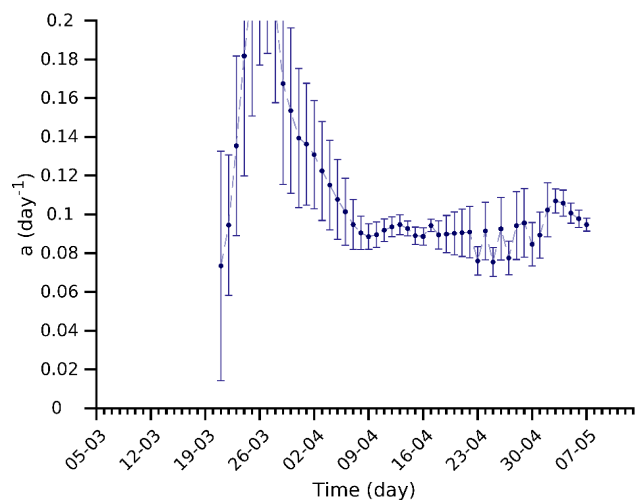
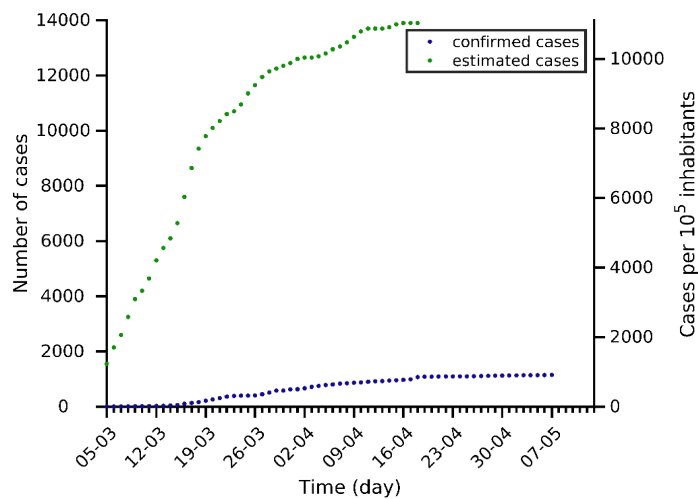
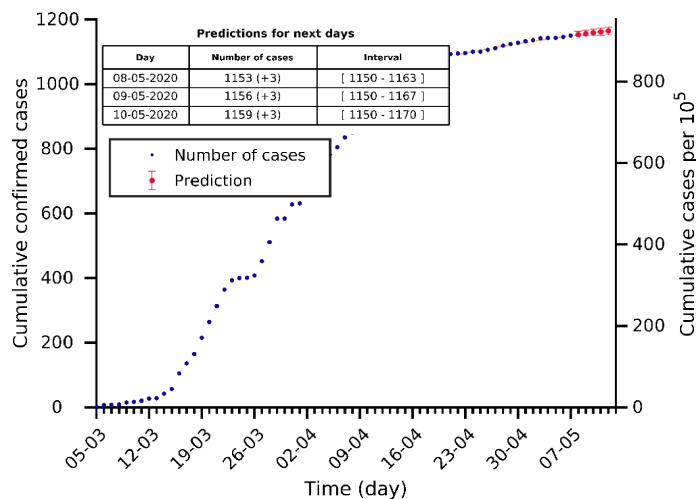
Umbria 07-05-2020. Population: 0.9M. Current cumulated incidence: 159/10⁵



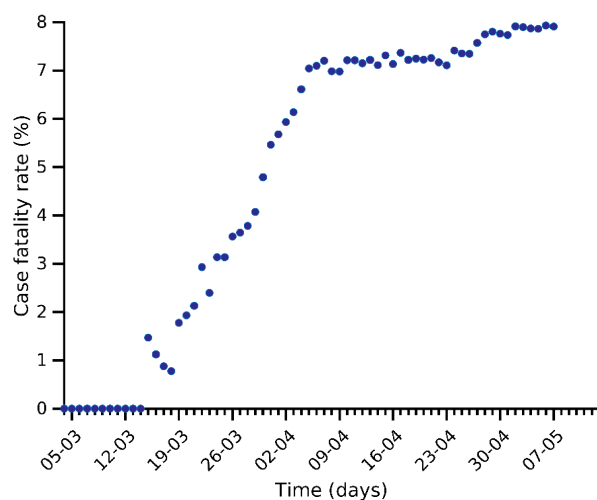
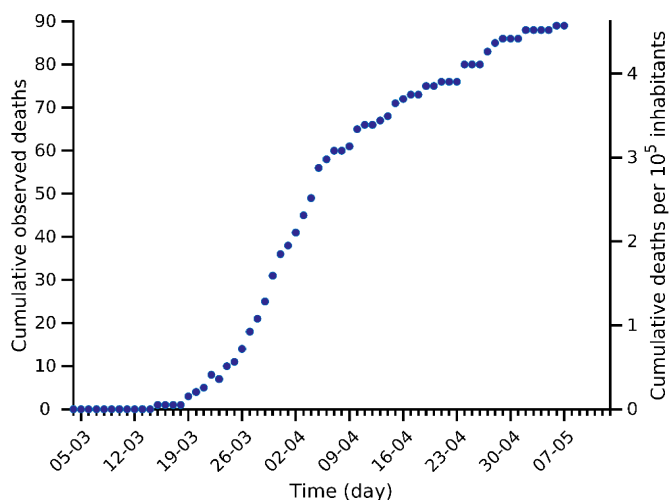
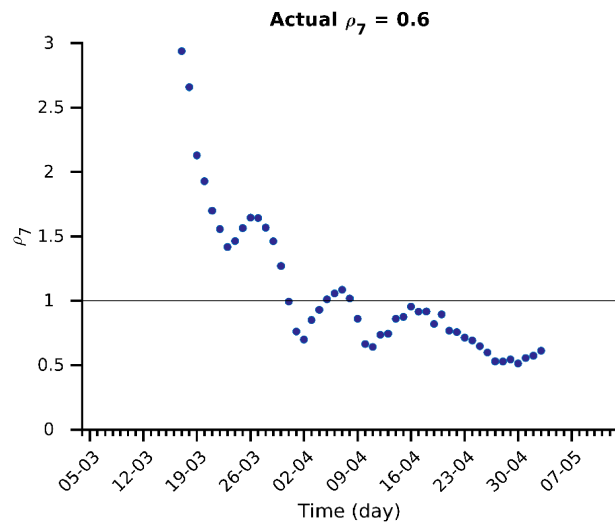
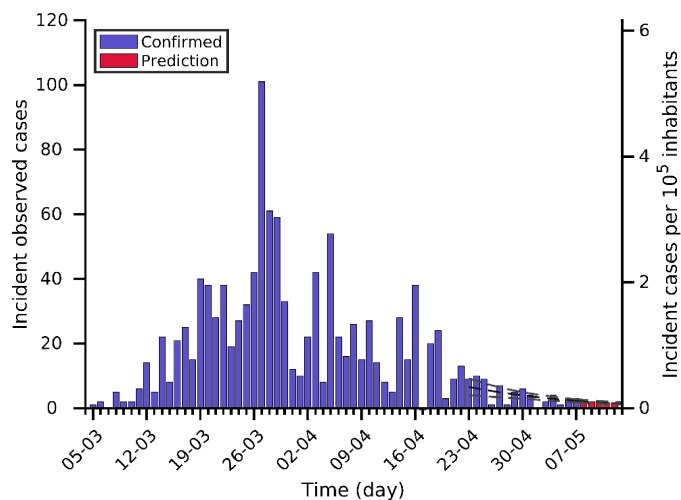
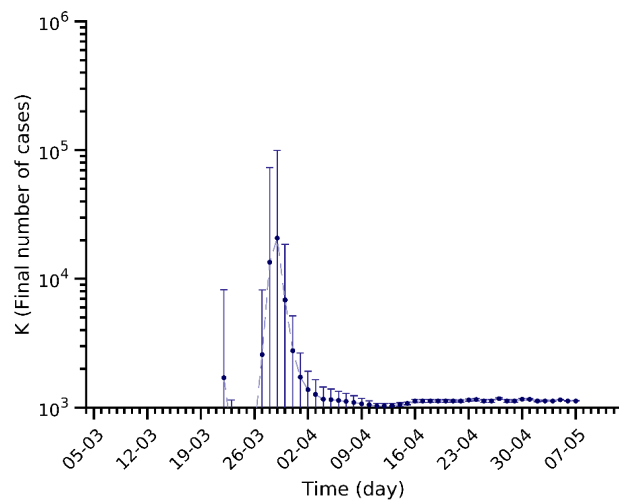
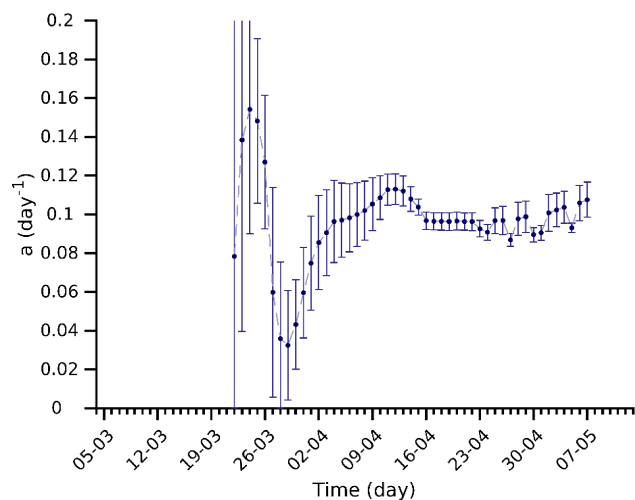
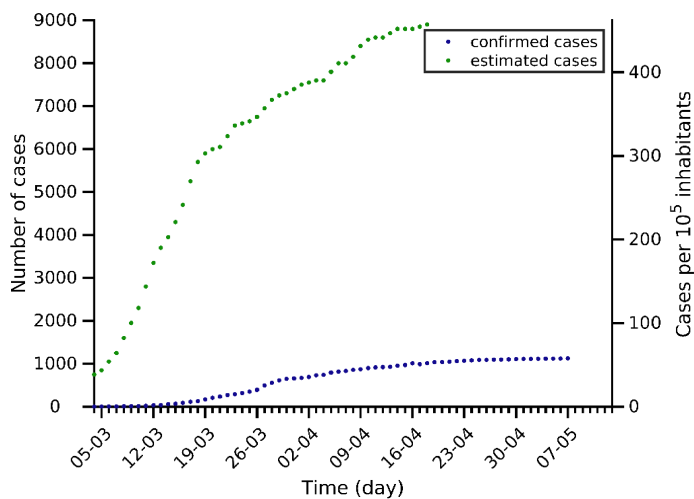
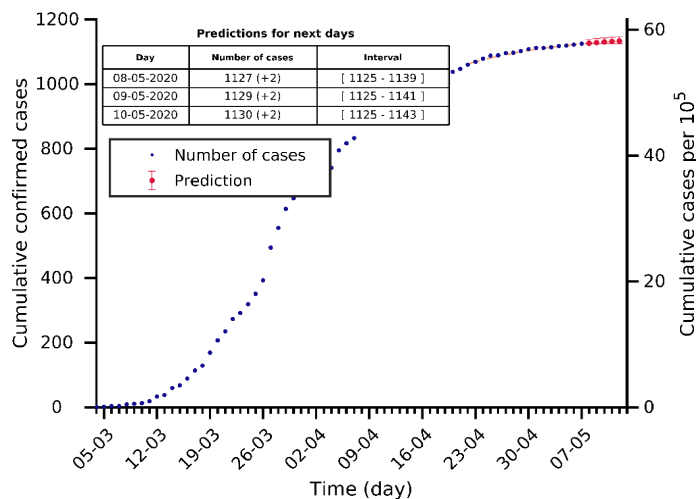
Sardegna 07-05-2020. Population: 1.6M. Current cumulated incidence: 81/10⁵

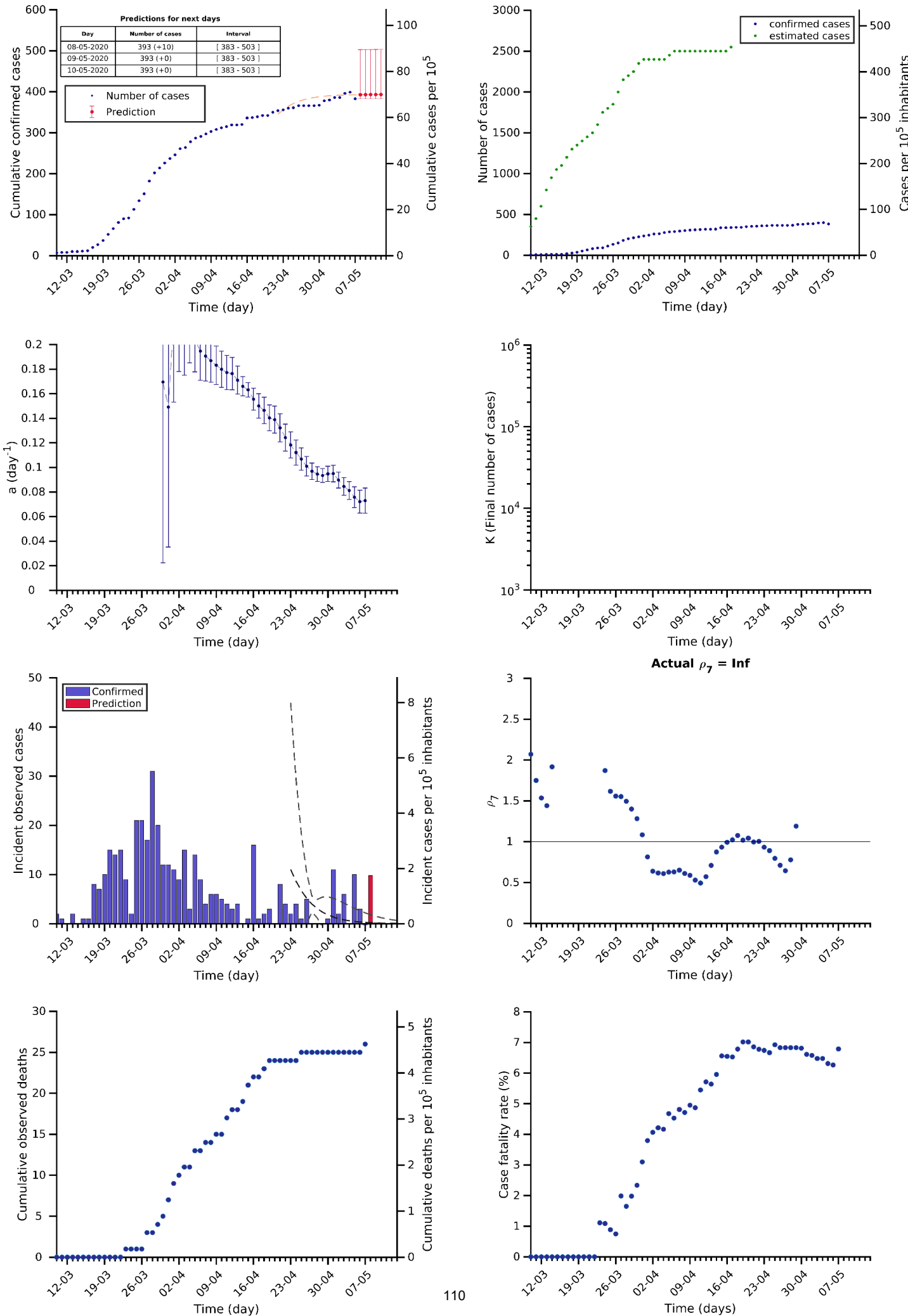


Valle d'Aosta 07-05-2020. Population: 0.1M. Current cumulated incidence: 913/10⁵

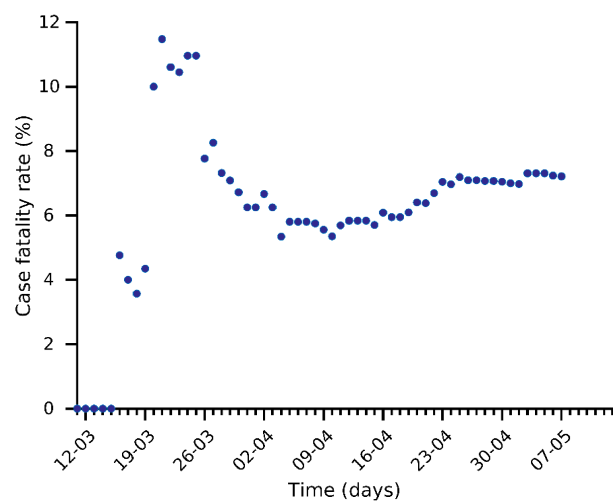
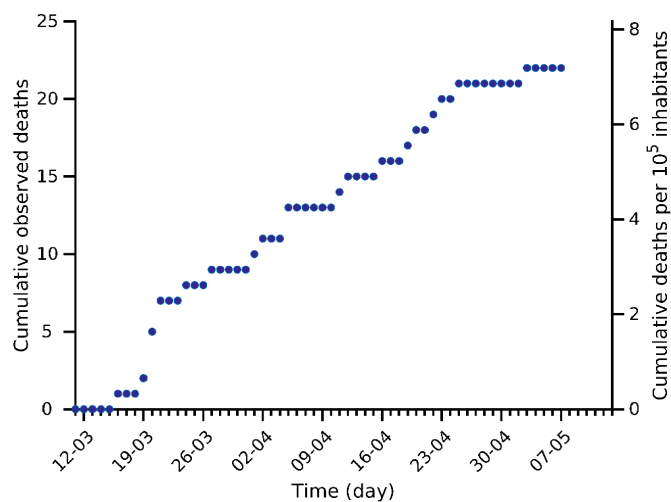
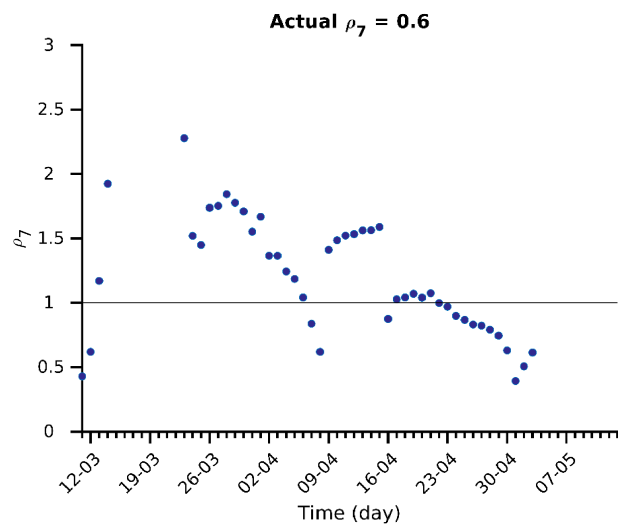
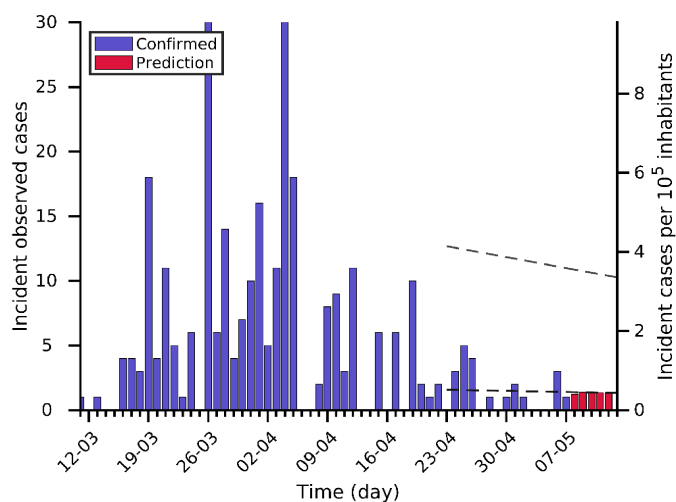
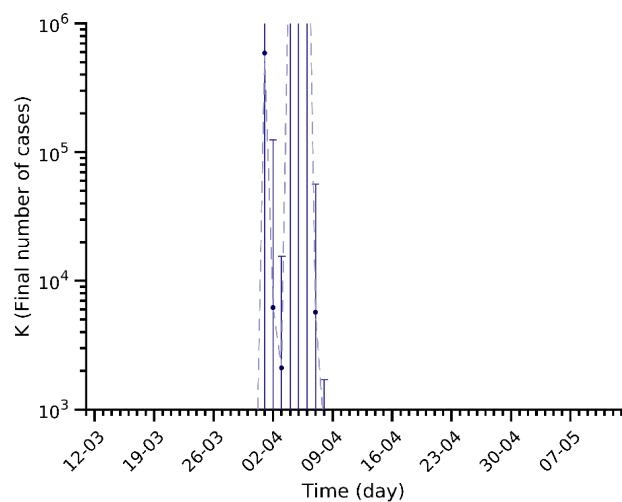
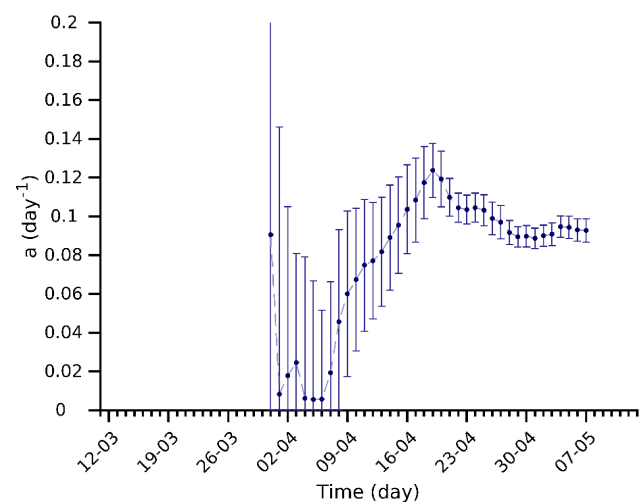
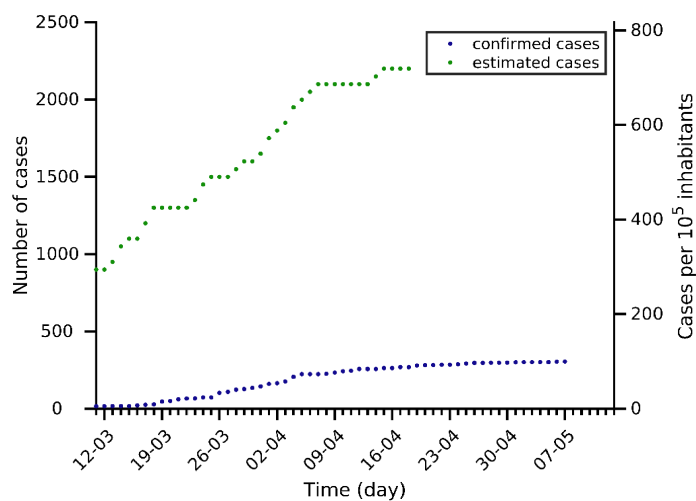
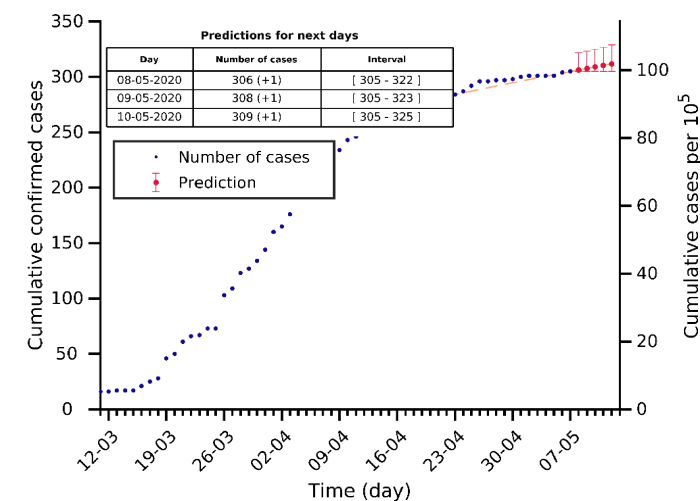


Calabria 07-05-2020. Population: 1.9M. Current cumulated incidence: 58/10⁵





Molise 07-05-2020. Population: 0.3M. Current cumulated incidence: 100/10⁵



Methods

Methods

(1) Data source

Data are daily obtained from World Health Organization (WHO) surveillance reports¹, from European Centre for Disease Prevention and Control (ECDC)² and from Ministerio de Sanidad³. These reports are converted into text files that can be processed for subsequent analysis. Daily data comprise, among others: total confirmed cases, total confirmed new cases, total deaths, total new deaths. It must be considered that the report is always providing data from previous day. In the document we use the date at which the datapoint is assumed to belong, i.e., report from 15/03/2020 is giving data from 14/03/2020, the latter being used in the subsequent analysis.

(2) Data processing and plotting

Data are initially processed with Matlab in order to update timeseries, i.e., last datapoints are added to historical sequences. These timeseries are plotted for EU individual countries and for the UE as a whole:

- ✓ Number of cumulated confirmed cases, in blue dots
- ✓ Number of reported new cases
- ✓ Number of cumulated deaths

Then, two indicators are calculated and plotted, too:

- ✓ Number of cumulated deaths divided by the number of cumulated confirmed cases, and reported as a percentage; it is an indirect indicator of the diagnostic level.
- ✓ ρ : this variable is related with the reproduction number, i.e., with the number of new infections caused by a single case. It is evaluated as follows for the day before last report ($t-1$):

$$\rho(t-1) = \frac{N_{new}(t) + N_{new}(t-1) + N_{new}(t-2)}{N_{new}(t-5) + N_{new}(t-6) + N_{new}(t-7)}$$

where $N_{new}(t)$ is the number of new confirmed cases at day t .

(3) Classification of countries according to their status in the epidemic cycle

The evolution of confirmed cases shows a biphasic behaviour:

- (I) an initial period where most of the cases are imported;
- (II) a subsequent period where most of new cases occur because of local transmission.

Once in the stage II, mathematical models can be used to track evolutions and predict tendencies. Focusing on countries that are on stage II, we classify them in three groups:

- Group A: countries that have reported more than 100 cumulated cases for 10 consecutive days or more;
- Group B: countries that have reported more than 100 cumulated cases for 7 to 9 consecutive days;
- Group C: countries that have reported more than 100 cumulated cases for 4 to 6 days.

¹ <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports>

² <https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases>

³ <https://www.mscbs.gob.es/profesionales/saludPublica/ccayes/alertasActual/nCov-China/situacionActual.htm>
<https://github.com/datadista/datasets/tree/master/COVID%2019> , <https://covid19.isciii.es/>

(4) Fitting a mathematical model to data

Previous studies have shown that Gompertz model⁴ correctly describes the Covid-19 epidemic in all analysed countries. It is an empirical model that starts with an exponential growth but that gradually decreases its specific growth rate. Therefore, it is adequate for describing an epidemic that is characterized by an initial exponential growth but a progressive decrease in spreading velocity provided that appropriate control measures are applied.

Gompertz model is described by the equation:

$$N(t) = K e^{-\ln\left(\frac{K}{N_0}\right) \cdot e^{-a \cdot (t-t_0)}}$$

where $N(t)$ is the cumulated number of confirmed cases at t (in days), and N_0 is the number of cumulated cases the day at day t_0 . The model has two parameters:

- ✓ a is the velocity at which specific spreading rate is slowing down;
- ✓ K is the expected final number of cumulated cases at the end of the epidemic.

This model is fitted to reported cumulated cases of the UE and of countries in stage II that accomplish two criteria: 4 or more consecutive days with more than 100 cumulated cases, and at least one datapoint over 200 cases. Day t_0 is chosen as that one at which $N(t)$ overpasses 100 cases. If more than 15 datapoints that accomplish the stated criteria are available, only the last 15 points are used. The fitting is done using Matlab's Curve Fitting package with Nonlinear Least Squares method, which also provides confidence intervals of fitted parameters (a and K) and the R^2 of the fitting. At the initial stages the dynamics is exponential and K cannot be correctly evaluated. In fact, at this stage the most relevant parameter is a . Fitted curves are incorporated to plots of cumulative reported cases with a dashed line. Once a new fitting is done, two plots are added to the country report:

- ✓ Evolution of fitted a with its error bars, i.e., values obtained on the fitting each day that the analysis has been carried out;
- ✓ Evolution of fitted K with its error bars, i.e., values obtained on the fitting each day that the analysis has been carried out; if lower error bar indicates a value that is lower than current number of cases, the error bar is truncated.

These plots illustrate the increase in fittings' confidence, as fitted values progressively stabilize around a certain value and error bars get smaller when the number of datapoints increases. In fact, in the case of countries, they are discarded and set as "Not enough data" if $a > 0.2 \text{ day}^{-1}$, if $K > 10^6$ or if the error in K overpasses 10^6 .

It is worth to mention that the simplicity of this model and the lack of previous assumptions about the Covid-19 behaviour make it appropriate for universal use, i.e., it can be fitted to any country independently of its socioeconomic context and control strategy. Then, the model is capable of quantifying the observed dynamics in an objective and standard manner and predicting short-term tendencies.

(5) Using the model for predicting short-term tendencies

The model is finally used for a short-term prediction of the evolution of the cumulated number of cases. The predictions increase their reliability with the number of datapoints used in the fitting. Therefore, we consider three levels of prediction, depending on the country:

⁴ Madden LV. Quantification of disease progression. Protection Ecology 1980; 2: 159-176.

- Group A: prediction of expected cumulated cases for the following 3-5 days⁵;
- Group B: prediction of expected cumulated cases for the following 2 days;
- Group C: prediction of expected cumulated cases for the following day.

The confidence interval of predictions is assessed with the Matlab function `predint`, with a 99% confidence level. These predictions are shown in the plots as red dots with corresponding error bars, and also gathered in the attached table. For series longer than 9 timepoints, last 3 points are weighted in the fitting so that changes in tendencies are well captured by the model.

(6) Estimating non-diagnosed cases

Lethality of Covid-19 has been estimated at around 1 % for Republic of Korea and the Diamond Princess cruise. Besides, median duration of viral shedding after Covid-19 onset has been estimated at 18.5 days for non-survivors⁶ in a retrospective study in Wuhan. These data allow for an estimation of total number of cases, considering that the number of deaths at certain moment should be about 1 % of total cases 18.5 days before. This is valid for estimating cases of countries at stage II, since in stage I the deaths would be mostly due to the incidence at the country from which they were imported. We establish a threshold of 50 reported cases before starting this estimation.

Reported deaths are passed through a moving average filter of 5 points in order to smooth tendencies. Then, the corresponding number of cases is found assuming the 1 % lethality. Finally, these cases are distributed between 18 and 19 days before each one.

⁵ At this moment we are testing predictions at 4 days for countries with more than 100 cumulated cases for 13-15 consecutive days, and 5 days for 16 or more days.

⁶ Zhou et al., 2020. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. The Lancet; March 9, doi: 10.1016/S0140-6736(20)30566-3